Appendix 5

Recommended Parking Ramp Design Guidelines

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City of Rochester, MN

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DMC Project No. Rochester J8618-J8622 Parking/TMA Study

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Parking Structure Design Guidelines

1. Introduction

This document was developed for the City of Rochester as a guide for future parking structure design in Downtown Rochester. It contains information to help developers and designers incorporate parking structure components into proposed projects. The concepts presented will help produce functional, well-designed and patron friendly parking structures that will become valued infrastructure elements for the Downtown. The concepts are presented so that common design mistakes can be avoided by being addressed early in the design process. Another important consideration in the development of these design guidelines is an anticipated increase the use of public/private partnerships going forward. Under this scenario, where the City could become a co-owner of a proposed parking development, having well-defined design guidelines up front and lead to better projects and improved development planning. The document should be periodically updated to reflect state-of-the-art parking design practices and principles.

To support this point, this document is an update to our original design guidelines document with the specific goal of incorporating recent advances in the area of "sustainable operations and management strategies". This addition nicely complements the DMC's plans that puts a greater emphasis on mobility management strategies. It includes the following categories:

- Introduction
- Project Delivery
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- Site Constraints

- Concept Design
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- Sustainable Ops & Mgmt. Checklist

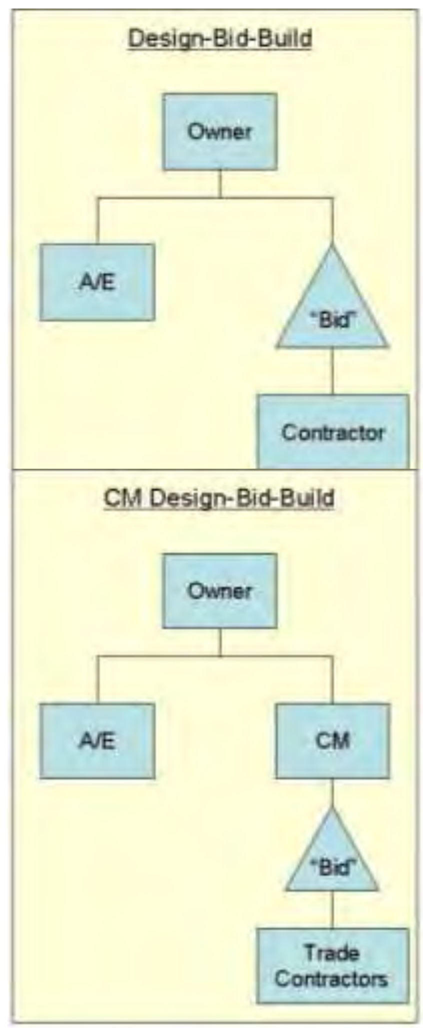
In any future parking development project, it is highly recommended that a qualified parking structure design specialty firm be engaged in the project due to the unique characteristics and special design expertise required to develop a successful project.

In addition to these design guidelines, we are also preparing a companion document that explores some innovative design thinking related to the potential for "future proofing" parking garage design in anticipation of potential parking demand reductions that could occur as the result of emerging shared mobility strategies and the potential impacts of the emergence of autonomous vehicles. In this companion document, we will explore the issues, strategies and alternative design concepts that could allow for the adaptive reuse of 40% – 50% of a traditional garage for other uses such as residential, office or other revenue producing options. Key issues such as structural capacity, floor-to-floor heights, maximizing flat floors, etc. will be addressed. The proposed approach will be illustrated in conceptual prototype designs that will flesh out the potential positive as well as negative issues associated with new approach.

2. Project Delivery

There are four primary project delivery methods commonly used to design and construct parking structures. Two design professional's handbooks titled the Design-Build Project Delivery and the Design/Contract-Build Project Delivery, published by the American Council of Engineering Companies (ACEC), are helpful references.

Each method is described on the following pages, along with a graphical depiction of the contractual relationships for each:

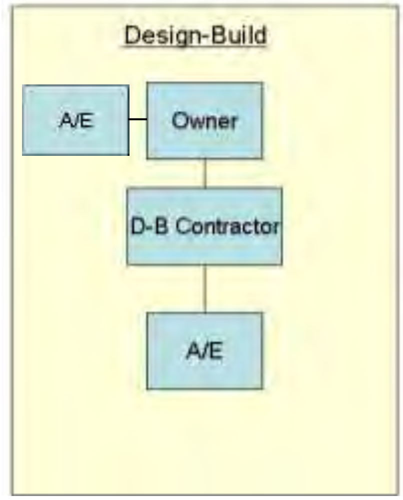


1. ***Design-Bid-Build*** (D-B-B) projects are those where the owner selects and contracts with the lead designer (Parking Consultant or Architect/Engineer). They in turn represent the owner in defining the project and preparing drawings and specifications to meet the owner's needs for competitive bidding to contractors. Often on public projects, the owner is required to select the lowest "responsive and responsible" bid, with the contractors' qualifications often not given consideration. The D-B-B method is sometimes referred to as the "traditional" process and is still the most common method.

2. ***Construction Manager - Design-Bid-Build*** (CM D-B-B) is where the owner selects and contracts with the architect/engineer (A/E) who represents the owner in defining the project and preparing drawings and specifications to meet the owner's needs for bidding. However, the owner also retains a construction manager (CM) who works with the A/E during the design phases, sets the project schedule, and performs construction

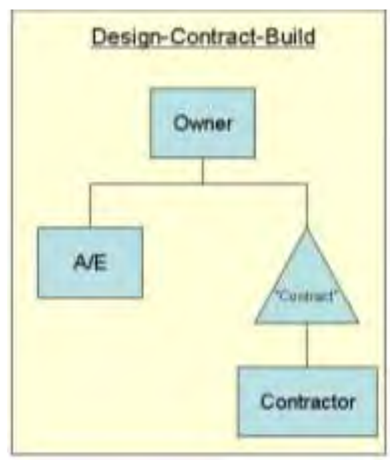
cost estimates. The CM bids the work to subcontractors for the various trades. This is a better method than D-B-B for projects where the owner wants fast track or phased construction.

3. ***Design-Build*** (D-B) are cases where the owner retains a D-B contractor who in turn retains the A/E so there is a single entity responsible for both design and construction. Often the owner prepares or retains another A/E to prepare design build criteria documents as described below. The owner can select the D-B team based on qualifications and cost, consistent with the bidding documents. There has been more interest in D-B type projects recently because of owners who perceive benefits regarding cost, schedule, and risk management.



*: Optional but recommended; A/E prepares design build criteria documents that are basis for contract with contractor.

4. ***Design-Contract-Build*** (D-C-B) are projects where the owner selects and contracts with the A/E. The A/E prepares preliminary documents that are the basis for the owner contracting with the contractor early in the design process, rather than waiting for final design documents to be prepared as for D-B-B. This method combines the advantages of the D-B-B and D-B methods while reducing many disadvantages to allow the owner to have the most qualified A/E and contractor involved in their project from the design phase through the completion of construction.



In recent years there has been an increasing interest and use of Design-Build in the construction of parking structures. Legislation has been enacted in many states to allow D-B to be used by public entities because prior laws required publicly funded construction contracts to be awarded based upon completed design documents.

Advantages of Design Build:

- Owner has a single point of responsibility for design and construction.
- Potential for better design and construction coordination because the A/E is working for the contractor.
- Owner does not have to arbitrate disputes between the A/E and contractor.
- Owner reduces their risk because the D/B contractor is responsible for errors or omissions in the design documents.
- Could be less administrative burden on the owner.
- Potential for accelerated schedule because the contractor is onboard at the beginning and because of the overlapping of design and construction work.
- Potential for lower costs due to the contractor being in greater control of the project and due to the accelerated schedule.
- Costs are well defined earlier in the process.

Disadvantages of Design Build:

- The D-B contractor has the incentive to complete projects faster and less expensively which can mean reduced quality of materials and workmanship.
- The owner has less involvement and control of the design because the A/E represents the D-B contractor's best interests, not the owner's. Not only is this a disadvantage for the owner, but it creates a difficult conflict of interest for the A/E.
- The owner does not benefit from independent advice and input from the A/E and contractor.
- Greater definition of the project is required up front to define goals, objectives, and minimum requirements for project function, appearance, quality, materials, operation, etc. prior to bidding to D-B teams.
- More risk for D-B teams, which can negate the potential cost saving opportunities.

When owners decide that D-B is right for their project, they can have a better chance of achieving a successful project utilizing the following procedures.

Recommendations Regarding the Design-Build Delivery Method:

1. The owner should retain an A/E at project initiation to prepare the D-B criteria documents. This allows the owner to have more input into the concept design and set standards and criteria for the project. Also, due to the uniqueness of parking structures, it is important to have the A/E led by a parking consultant or for a parking consultant to have a significant role on the design team.

Parking structure built for Baylor University using the Design-Build delivery method

2. D-B criteria documents should clearly define the project scope, function, appearance, quality, materials, and operations. The level of completeness of these documents varies, but generally they are in the 10 to 30 percent range (between Schematic Design and Design Development level of completeness).

3. The owner should use a very transparent selection process to hire the D-B contractor, using the D-B criteria documents as the basis of the Request for Qualifications/Proposals (RFQ/RFP).

4. The selection process should consider the D-B teams' technical qualifications and experience in addition to cost. Typically, there is a weighting of selection criteria such as the experience and expertise of the firms and key personnel making up the team, experience of the team working together, technical merits of design, project appearance, quality and safety programs of the contractor, references, schedule, and cost. The selection criteria and weighting should be defined in the RFQ/RFP.

5. The owner's A/E who prepared the D-B criteria documents should continue on during the final design and construction to represent the owner's interest and help assure that the design and construction are completed in conformance with the D-B criteria documents.

- As an alternative to using the D-B method, the D-C-B or CM methods can often result in a project that meets the owner's best interests because:

- The A/E contracts to the owner, thus representing their interests, not the contractor's, which should enhance quality
- Design decisions can more easily be made that are in the best long-term interest of the owner, considering factors that will provide the lowest life cycle maintenance or operational cost, rather than emphasizing those that just provide the lowest first cost or schedule advantage
- The CM or contractor is onboard early in the design process so the A/E and contractor collaborate during design, enhancing innovation and opportunities to consider the contractor's cost saving ideas
- Similar schedule and cost advantages compared to D-B
- Less risk for all parties as responsibilities can be allocated where they are appropriate

Successful parking structure projects have been completed using all four of the construction methods discussed above. Understanding the advantages and disadvantages of each and following a process to address them will help assure that the completed project is a success for the user, owner, community, designer and builder.

3. Sustainable Design and Accreditation

While it is possible for parking structures to achieve certification, typically only occupied buildings receive certification for their sustainable design through the U.S. Green Building Councils (USGBC) Leadership in Energy and Environmental Design (LEED) accreditation program. However, parking structures that are part of a mixed use project can help attain LEED points for the entire building project. The fact that stand-alone parking structures are generally not eligible for LEED certification should not discourage including sustainable design elements in parking structures.

Note: The Green Parking Council was recently acquired by the Green Building Certification, Inc. (GBCI), the certification body for US Green Building Council's (USGBC) global LEED green building rating system, which will now administer the Green Garage Certification Program.

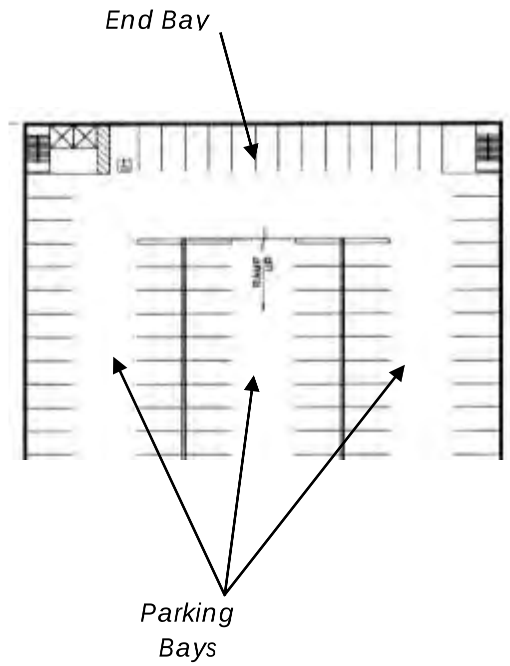
Examples of sustainable design features for parking structures include:

- Sustainable Site Development
    - Green roofs
    - Solar panel sunshades on the top levels

- Alternative transportation accommodations

- Water Savings
  - Water-efficient landscaping
  - Irrigation using non-potable water
  - Innovative technologies for water retention/detention
- Energy Efficiency
  - Energy efficient light sources such as natural lighting, fluorescent, induction, and light emitting diodes (LED)
  - Photovoltaic solar panels
  - Computerized lighting controls and voltage reduction
- Materials and Resources Selection
  - Reuse of existing facades or shell
  - Use of recycled materials such as silica fume, fly ash, and steel
  - Carbon fiber reinforcement
  - Thin brick façade panels
  - Recycled rubber
- Indoor Environmental Quality
  - Low VOC products (e.g., paint, sealers and coatings)
  - CO monitoring and venting
  - Maximum natural ventilation and lighting (e.g., interior light wells)
  - Sustainable cleaning products
- Innovation and Design Process
  - Multi-modal facilities
  - Automated parking facilities on smaller site footprints
  - Designs for 75-100 year life
  - Bicycle storage lockers

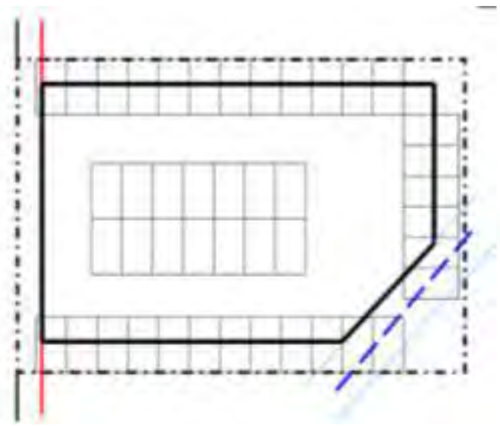
4. Site Requirements



Large and rectangular shaped sites are ideal for parking structures. Although flat sites are generally more economical to develop, sloped sites can provide design opportunities such as access on different levels and/or no ramping between levels. For a reasonably efficient parking layout, double-loaded parking "bays" range in width from about 54 to 60 feet, depending upon the angle of parking and the width of the parking space. The overall width of the structure should be determined based upon multiples of the chosen parking bay width. An ideal length for a parking structure is at least 240 feet. Longer sites provide the opportunity to park along the end bays, which provides more parking spaces, improves efficiency, and lowers the cost per space. A longer site also allows for shallower ramps which provide improved user comfort.

Generally, parking bays should be oriented parallel to the longer dimension of the site and preferably in the predominate direction of pedestrian travel. Walking distance tolerances from parking to a primary destination are typically 200 to 300 feet for shoppers, 500 to 800 feet for downtown employees, and 1,500 to 2,000 feet for special event patrons and students.

5. Site Constraints



Other site issues to be considered when evaluating a potential site for a suitable parking facility include the following:

- Site Survey – a topographic survey of the site is a very important precursor to develop a conceptual plan. The site survey should delineate property lines, easements, and utility lines.
- Site Slope – The topographic information will define the slope of the site. Sometimes the slope of a site can utilized to reduce internal ramping in a parking structure, resulting in significantly lower costs (however, this should be weighed against operational concerns created by the inability to circulate within the structure). A parking structure that is built into a hillside can also reduce the visual mass of the facility.
- Geotechnical & Soils – Obtaining a soils report with sample borings and a geotechnical analysis early in the design process is prudent. If soils with poor bearing capacity are present on the site, the added cost for structural foundations can be significant.
- Codes and Ordinances – Municipal ordinances often specify setbacks, building height and bulk limitations, floor area ratio to site area, etc. that can significantly affect the allowable area on a site for a parking structure. The local planning organization may also impose development guidelines that must be followed.

6. Concept Design

Much of the remainder of these guidelines addresses issues and elements of parking structures that should be considerations during the conceptual design phase.

Parking Structures for People

An overall design principal to keep in mind is that parking structures are for people. Designing to accommodate the users of a particular structure will help produce a better parking structure.

- Different user types will have different needs
- Some user types may need to be physically separated to ensure revenue control or for security reasons
- Different users require different pedestrian circulation systems
- Parking space widths and circulation geometry needs vary depending on the user type.
- Some vehicular circulation systems are better for specific user types:
    - Residential – Regular users enter and exit two times a day.
    - Education – May have peak loads in and out.
    - Hotel – Overnight guests, maybe event parking too.
    - Office – Low turnover. Regular users enter and exit two times a day.
    - Health Care Visitors – Wayfinding very important. Need to accommodate elderly drivers and passengers.
    - Health Care Staff – Shift time overlap and loading. Security issues, particularly at night.
    - Retail – High turnover. Occasional users - wayfinding to and from vehicle.

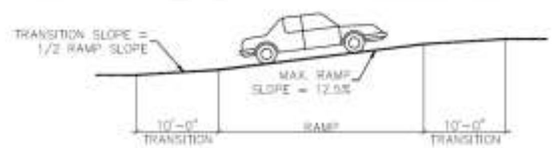
- Elderly or Families with Small Children – Wayfinding again important. May need larger spaces and more elevators.
- Events – Easy quick loading and unloading of structure. Multiple vehicular paths. Consider revenue collection methods, typically a flat fee on entry. Provide queuing space. Consider pedestrian flow to event - avoid crossing traffic.
- Multiuse Garages – These guidelines focus on parking garage design for downtown Boise. Most of the garages in downtown will serve at least two user groups – short-term and long-term parkers – and may serve many other user groups. This is due to the fact that future garages will be located in activity centers that include office, entertainment, special event, restaurants, retail, lodging, and residential land uses – all of which have different parking characteristics. Attention should be given to creating entry, exit, and circulation designs that are flexible and adaptable to particular situations. Dual exit lanes that allow parkers with passes to exit quickly without having to wait in line with parkers who are paying should be considered to lower frustration levels for customers.

7. Circulation and Ramping

The basic circulation element for a parking structure is the continuous ramp with parking on both sides of the drive aisle. In continuous ramp structures, some of the parking floors are sloped in order for traffic to circulate from one level to another. Only on a sloping site that permits direct access to each level from the exterior roadways are ramps unnecessary; but they still may be desirable for internal circulation.

The basic criteria for choosing a circulation system are the simplicity or complexity of the system and the architectural compatibility. Ingress and egress capacities are also a consideration in the selection of a circulation system. Some circulation systems provide the opportunity for level façades which may be desirable.

A parking ramp slope of 5% or less is preferred, although parking ramp slopes up to 7% are tolerated by the public in very dense urban areas. Parking ramp slopes should not exceed a 6.67% slope, which is the maximum parking slope permitted in the International Building Code (IBC). The acceptable ramp slope must also conform to the current Boise City Building Code.



Non-parking ramps are often employed at airports, casinos, large retail structures, for special event structures, and on small and irregularly shaped sites. Non-parking ramps consist of circular helixes (most common), express ramps (external), and speed ramps (internal). Non-parking ramp slopes should have a maximum slope in the 12% to 14% range. Non-parking ramp slopes up to 20% are sometimes considered if covered or equipped with snow melt systems.

Parking structures with non-parking ramps tend to be less efficient in terms of square feet of structure per parking space which directly increases the construction cost per parking space.

A grade difference of 8% or more requires transition slopes so vehicles do not "bottom out". Recommended are minimum 10'-0" transition slopes at the top and bottom of the ramp that are one-half of the differential slope. For instance, two 10'-0" transition ramps sloped at 6.25% would be required at the bottom and the top of a ramp sloped at 12.5%.

8. One-Way vs. Two-Way Traffic

One of the primary factors in the design of parking structure is determining the traffic flow: one-way or two-way. Typically, a parking bay for a one-way traffic flow is narrower than for a two-way flow. The available site dimensions will influence the parking bay width and thus also influence the circulation pattern. There are advantages and disadvantages to both circulation patterns. One-way traffic flow should never be combined with 90° parking. In parking facilities with one-way traffic flow, the angle of the parking stalls establishes the direction of vehicle traffic.

Advantages of One-Way Traffic Flow:

- Easier for parkers to enter/exit parking spaces.
- Vehicles are more likely to be centered in angled spaces.
- Less circulation conflict and reduced potential for accidents.
- Better visibility when backing out of a stall.
- Separation of inbound and outbound traffic and improved flow capacity of the circulation system.
- The intended traffic flow is self-enforcing.
- One-way traffic allows the angle of parking to be changed to accommodate changes in vehicle sizes

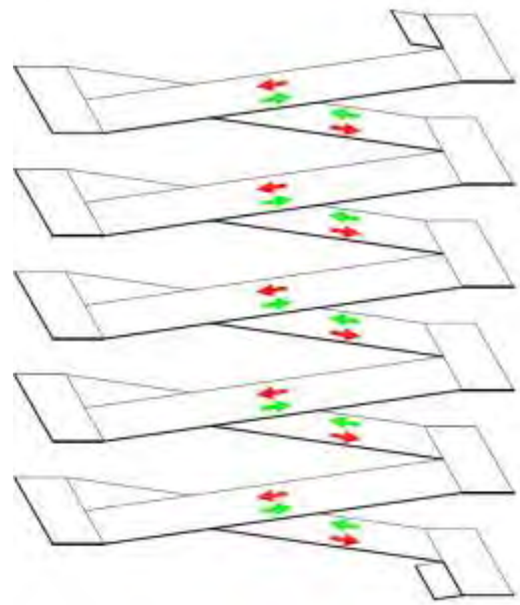
Advantages of Two-Way Traffic Flow:

- Wider drive aisles allow parkers to pass other vehicles.
- Wider drive aisles are safer for pedestrians.
- Better angle of visibility when searching for a parking space.
- Traffic flow follows its own pattern rather than one that is forced.
- Two-way traffic and 90° parking makes more efficient use of parking aisles (more spaces in a run).
- Two-way parking facilities can essentially operate as one-way facilities when there is heavy directional traffic.

Single Threaded Design

In order to develop a reasonably efficient free-standing parking structure, the **minimum** dimensions needed are about 122 feet in width by 155 feet in length. A width of 122 feet allows for a two-bay facility with two-way traffic flow and 90-degree parking. A facility with two-way traffic and a five-foot rise along each bay requires approximately 155 feet in length for a minimum floor-to-floor height of about ten feet. That is, one 360-degree turn within the facility equates to a vertical rise of ten feet. A structure in this configuration has sloping floors along both façade sides. However, sloping floors can make façade treatments challenging. On larger sites that allow a structure length of about 255 feet, one bay can be sloped rising 10 feet with opposite façade having a "level" floor.

Because of the number of 360º turns needed to ascend in a single threaded structure, the number of levels (floors) should preferably be limited to a maximum of six, otherwise the number of turns required and the number of spaces passed becomes inconvenient. A structure with a two-bay single thread design has a capacity for a maximum of approximately 750 spaces. The isometric diagram to the right represents a two-bay single-threaded helix.

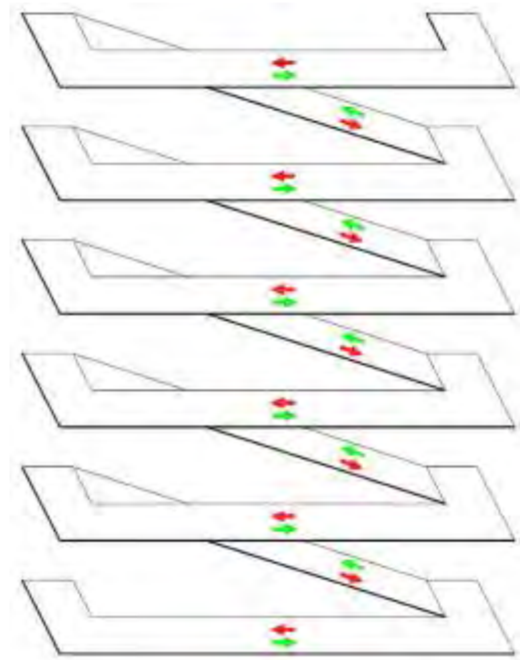


Single Threaded Helix with Sloping Floors

Principal Advantages of a Single-Threaded Helix:

- Repetitive and easy to understand for users.
- Potentially more flat-floor parking and level façade elements.
- Better visibility across the structure, which enhances security.

Principal Disadvantages of a Single-Threaded Helix:

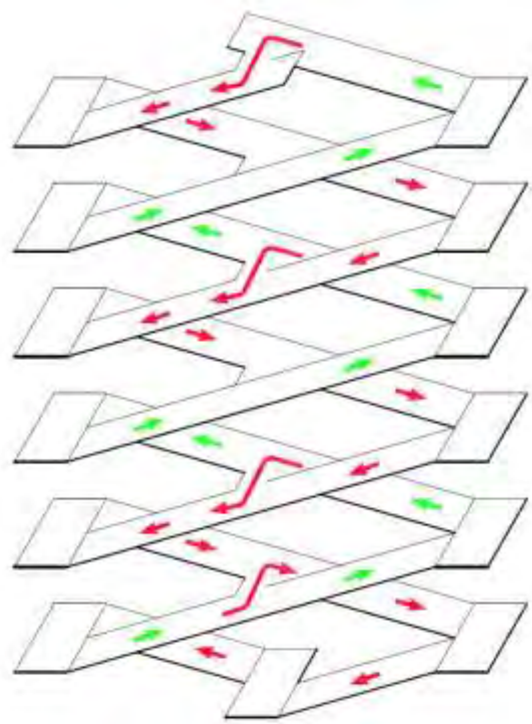


Single Threaded Helix with One Level Bay

- More revolutions required going from bottom to top and top to bottom.
- Two-way traffic bays have less flow capacity than one-way traffic bays. Traffic in both directions is impeded by vehicles parking and vacating a space.

Double Threaded Design

A facility with a one-way circulation system and angled parking can be provided in a double-threaded helix with modules ranging from 54 to 58 feet in width, depending upon the angle of parking. The preferred angles of parking for an efficient layout are 60°, 70° and 75°. A double thread, which requires a ten-foot rise along each module, requires 240 feet in length. More efficient layouts can be achieved on longer sites. The isometric to the right represents a two-bay double-threaded helix with one-way traffic.



One Way Double Threaded Design

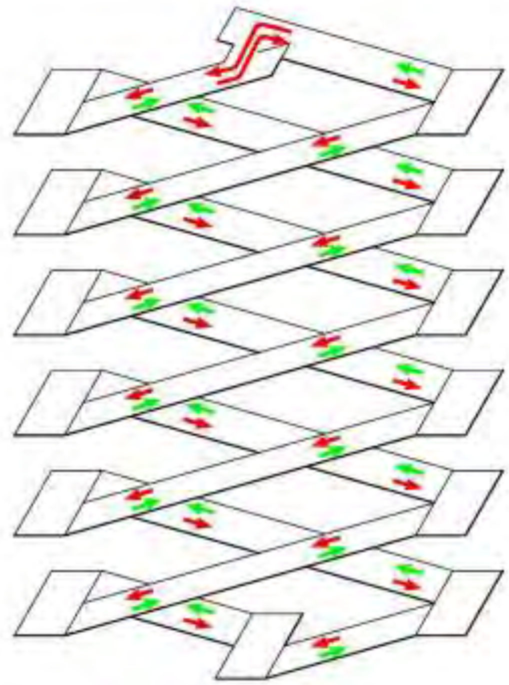
A double-threaded helix can work with either one-way or two-way traffic flow, although one-way traffic is more common. A two-way double threaded design can be configured as two separate structures with no vehicular connection. A double-threaded helix rises two levels with every 360 degrees of revolution, which allows for two intertwined "threads" and the opportunity to circulate to an available parking space without passing all parking spaces as inbound and outbound traffic can be separated. Because of this, double-threaded helixes are often recommended for larger facilities with seven or more levels. A two-bay double thread has a functional system capacity for up to approximately 2,000 spaces with angled parking and one-way traffic flow.

Principal Advantages of a Double-Threaded Helix:

- Efficient circulation and more traffic flow capacity
- Pass fewer spaces both inbound and outbound.

Principal Disadvantages of a Double-Threaded Helix:

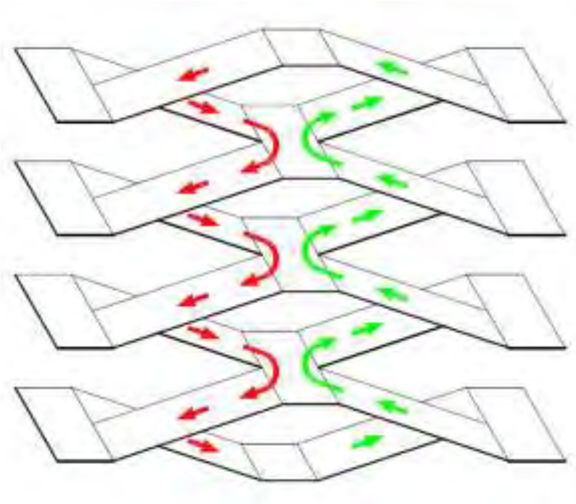
- Can be complex and confusing, particularly in finding one's vehicle upon return to the parking facility.
- Two-sloped bays and minimal flat-floor parking.



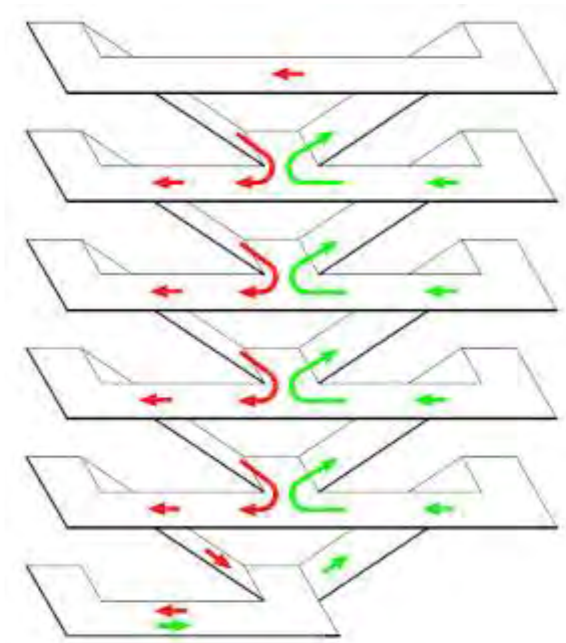
Two Way Double Threaded Design

9. Other Circulation Systems

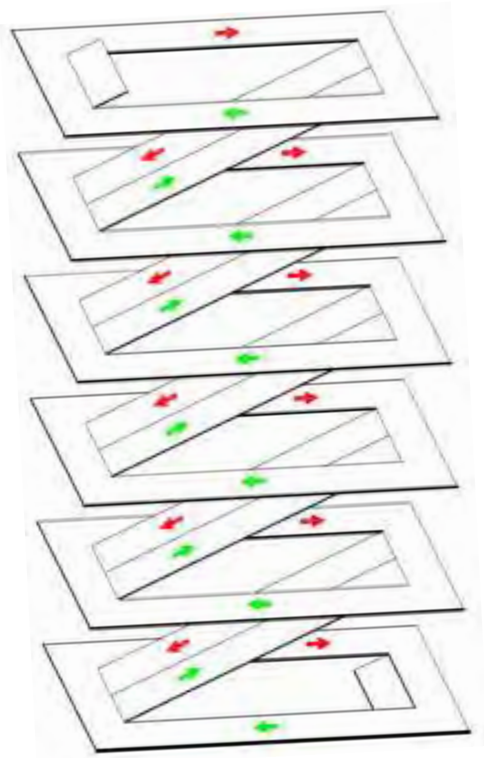
There are other parking and circulation systems that are often used in parking structures. Examples are provided below.



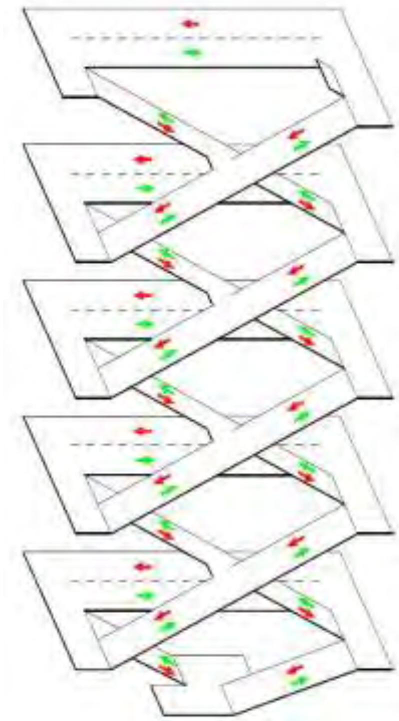
End-to-End Helix Both Bays Sloped



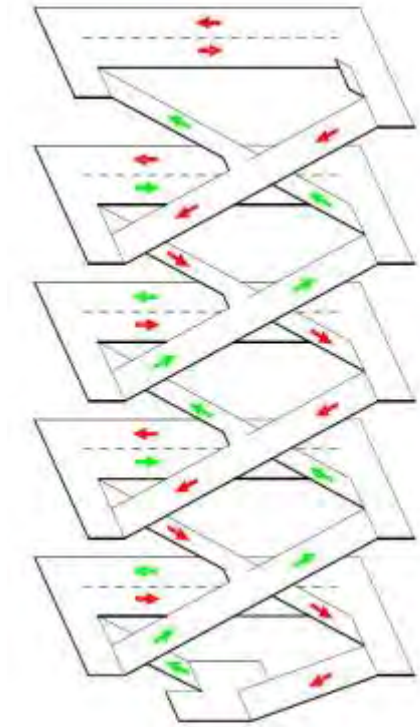
End-to-End Helix One Bay Sloped



Side-by-Side Helix



Two-way Double Threaded w/ Flat Bays



One-way Double Threaded w/ Flat Bays

10. Access Design

Vehicle entrances should be visible and easily identifiable. The minimum distance of entry/exits from corner intersections is at least 75 to 100 feet (preferably 150 feet). Entrances and exits should have clear lines of sight. It is preferable to enter a facility from a one-way street or by turning right from a two-way street and to exit a facility by turning right on a low-volume street. High traffic volumes and left turns can slow exiting and cause internal traffic backups. Consideration should be given to acceleration/deceleration lanes on busy streets. Gates should be located far enough away from the street to allow at least one vehicle behind the vehicle in the service position (at a ticket dispenser, card reader or cashier booth) without blocking the sidewalk. Entry/exit areas that have parking control equipment should have a maximum 3% slope.

Important Issues for Vehicle Entry and Exit Lanes:

- The approach and the departure area from the lanes will also affect the rate of flow into or out of the structure. Tight turns equal a slower throughput.
- Pedestrian safety at entry and exit portals is paramount. Consider the vision cone of drivers entering or exiting the facility. Utilize "transitional lighting" at entry/exits.
- Check and recheck vehicle turning radii at all entry / exit lanes and adjacent ramps.
- Vehicle queuing analyses should be performed to ensure traffic does not back-up onto the exiting street system or the inside of the facility during peak periods of traffic flow.

It is very important to provide the appropriate number of entry/exit lanes to meet projected peak traffic volumes. The number of lanes is a function of user groups served, peak-hour traffic volumes, and service rates of the parking control equipment. It is recommended to have a parking professional prepare a lane and queuing analysis to guarantee sufficient entry and exit capacities.

Cross-traffic at entry/exits should be minimized and preferably eliminated. When placing vehicle entries and exits together on one-way streets it is preferable to avoid "English" traffic conditions where traffic keeps to the left instead of to the right. Pedestrian/vehicular conflicts should be minimized by providing a pedestrian walkway adjacent to entry/exit lanes. Stair/elevator towers should be located so pedestrians do not have to cross drive aisles on their way to primary destinations.

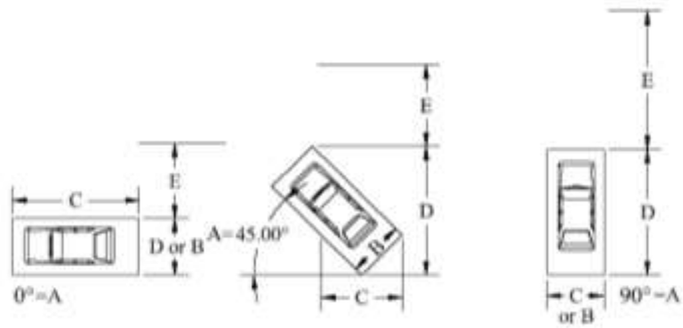
11. Parking Geometrics

Parking geometrics refers to parking stall and drive aisle dimensions. Parking dimensions have been developed to comfortably accommodate the composite design vehicle, which refers to the dimensions of the 85th percentile vehicle in the range of vehicles from smallest (zero percentile) to largest (100th percentile). The composite design vehicle is the size of a Ford F150 truck (6'-7" x 17'-3").

Parking Angle A	Stall Width B	Curb Length Per Car C	Stall Depth D	Driveway Width E
0°	9'-0"	23'-0"	9'-0"	12'-0"
20°	9'-0"	26'-4"	15'-3"	11'-0"
30°	9'-0"	18'-0"	17'-8"	11'-0"
40°	9'-0"	14'-0"	19'-6"	12'-0"
45°	9'-0"	12'-9"	20'-5"	13'-0"
50°	9'-0"	11'-9"	21'-0"	14'-0"
60°	9'-0"	10'-5"	21'-10"	16'-0"
70°	9'-0"	9'-8"	21'-10"	18'-0"
80°	9'-0"	9'-2"	21'-4"	20'-0"
90°	9'-0"	9'-0"	20'-0"	22'-0"

MINIMUM STANDARDS FOR COMPACT VEHICLES

Parking Angle A	Stall Width B	Curb Length Per Car C	Stall Depth D	Driveway Width E
45°	7'-6"	10'-6"	16'-0"	11'-0"
60°	7'-6"	8'-9"	16'-9"	14'-0"
75°	7'-6"	7'-10"	16'-4"	17'-5"
90°	7'-6"	7'-6"	15'-0"	20'-0"



The table on this page lists City of Boise parking geometrics by parking angle for standard and compact spaces.

The city's parking dimensions for standard spaces exceed industry standards. The table on the following page lists parking geometrics by User Comfort Factor (UCF) which correlates with a Level of Service (LOS) approach. Traffic engineers developed the LOS approach to classify traffic conditions on roadways from A (free flow) to F (gridlock). The UCF/LOS approach has been adopted by many parking consultants to help classify conditions in parking facilities. The recommended UCF categories for parking geometrics are as follows:

UCF 4 = LOS A = Excellent

UCF 3 = LOS B = Good

UCF 2 = LOS C = Acceptable

LOS criteria should be related to the needs and concerns of users. Generally, users with low familiarity and high turnover should be accorded a higher UCF. If the city's parking standards are not used, we recommend minimum UCF 3 geometrics for moderate to high turnover parking (visitor, retail, etc.) and minimum UCF 2 geometrics for low turnover parking (employee, commuter, resident, etc.).

We recommend using "one-size-fits-all" parking spaces rather than segregating standard and small car spaces. However, if they are used, small car spaces should not exceed 15% to 20% of the total capacity of a facility.

Although parking garages can be custom designed to fit most sites of adequate size, in general, the minimum footprint dimensions for an "efficient parking garage" (in terms of square feet per stall) is approximately 125' x 300'. A base parking stall dimension, for most uses should be approximately 9.0' x 18.0'.

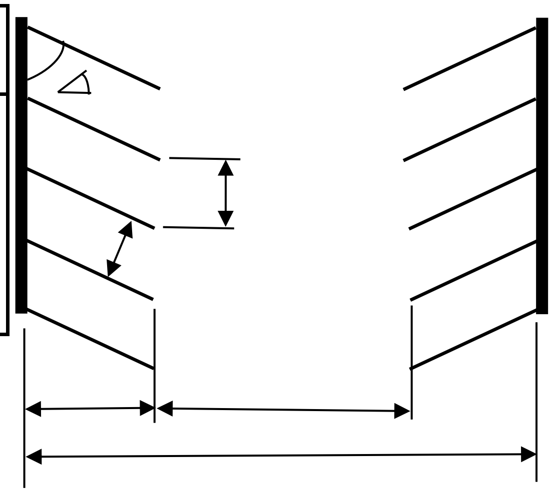
12. Parking Layout Dimensions

The following tables summarize parking layout dimensions by User Comfort Factor categories.

PARKING LAYOUT DIMENSIONS

Parking Angle	Stall Width Projection (WP)	Module Width (1) (MW)	Vehicle Projection (VP)	Aisle Width (AW)
User Comfort Factor 4				
w = 9'-0"				
45	12'-9"	49'-10"	17'-7"	14'-8"
50	11'-9"	51'-7"	18'-2"	15'-3"
55	11'-0"	53'-0"	18'-8"	15'-8"
60	10'-5"	54'-6"	19'-0"	16'-6"
65	9'-11"	55'-9"	19'-2"	17'-5"
70	9'-7"	57'-0"	19'-3"	18'-6"
75	9'-4"	58'-0"	19'-1"	19'-10"
90	9'-0"	62'-0"	18'-0"	26'-0"
User Comfort Factor 3				
w = 8'-9"				
45	12'-4"	48'-10"	17'-7"	13'-8"
50	11'-5"	50'-7"	18'-2"	14'-3"
55	10'-8"	52'-0"	18'-8"	14'-8"
60	10'-1"	53'-6"	19'-0"	15'-6"
65	9'-8"	54'-9"	19'-2"	16'-5"
70	9'-4"	56'-0"	19'-3"	17'-6"
75	9'-1"	57'-0"	19'-1"	18'-10"
90	8'-9"	61'-0"	18'-0"	25'-0"

Parking Angle	Stall Width Projection (WP)	Module Width (1) (MW)	Vehicle Projection (VP)	Aisle Width (AW)
User Comfort Factor 2				
w = 8'-6"				
45	12'-0"	47'-10"	17'-7"	12'-8"
50	11'-1"	49'-7"	18'-2"	13'-3"
55	10'-5"	51'-0"	18'-8"	13'-8"
60	9'-10"	52'-6"	19'-0"	14'-6"
65	9'-5"	53'-9"	19'-2"	15'-5"
70	9'-1"	55'-0"	19'-3"	16'-6"
75	8'-10"	56'-0"	19'-1"	17'-10"
90	8'-6"	60'-0"	18'-0"	24'-0"

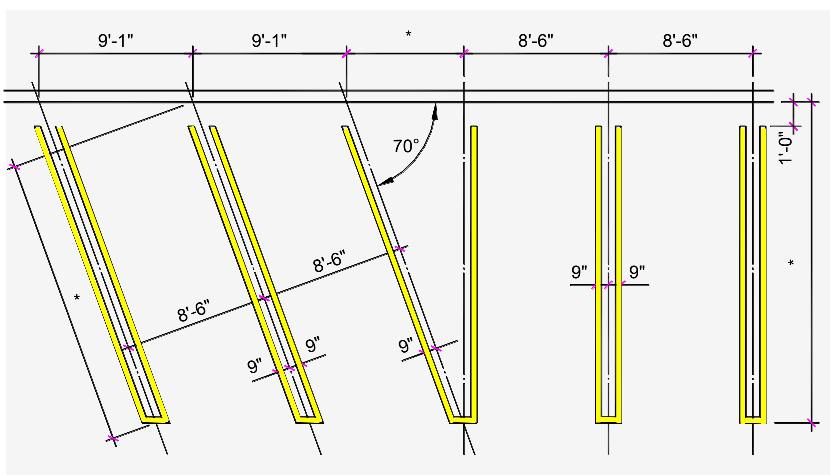


Note: (1) Wall to wall, double loaded aisle.

Parking spaces adjacent to walls, columns, elevators, stairs, etc. should be widened, if possible, by one foot so that vehicle doors can be more easily opened.

End bay drive aisles with two-way traffic should be a minimum of 26' wide for improved turning maneuverability. Wider end bay drive aisles are recommended for high turnover parking facilities. If possible, it is also suggested for more comfortable turns to hold back the first stall on either side of the turning bay. Small-Car-Only (SCO) spaces are also recommended at the ends of interior parking rows. It is very difficult to make a turn around only one row of parking. Refer to the following graphic.

Double stripes for space striping are recommended as they help parkers center their vehicles between stripes, maximizing the space between vehicles (refer to the graphic below). Also recommended is the use of traffic yellow paint for stall striping as yellow paint is more visible over time than white paint.



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13. Parking Layout Efficiency

Parking efficiency is expressed in square feet of construction per parking space. Parking efficiency directly correlates with the construction cost per space. Build less structure per space and the cost per space drops. Non-parking speed ramps for example increase the square feet per space.

Parking efficiency should be calculated considering the total parking structure size including the stairs and elevators and non-parking ramps. Any retail space that is incorporated within the structure is also usually included in the calculation.

- Typical ranges of parking structure efficiencies are:
- Short Span Structural System = 330 to 390 Square Feet per Space
- Long Span Structural System = 300 to 340 Square Feet per Space
- Mixed Use Developments with retail, residential and parking can be as high as 400+ square feet per space

PARKING EFFICIENCY MAKES A BIG DIFFERENCE – EXAMPLE

- 360 sf / space X 500 spaces X $45 / sf = $8,100,000
- 330 sf / space X 500 spaces X $45 / sf = $7,425,000

A difference of $675,000 or $1,350 per space!

14. Pedestrian Requirements

Pedestrian traffic is equally as important in a parking structure as vehicle traffic. A safe, secure and well signed pedestrian path must be provided. Pedestrian access at the grade level should be separated from vehicular ingress and egress. Pedestrian access is usually adjacent to stair/elevator towers. It is also desirable to place a dedicated pedestrian aisle adjacent to a vehicle entry/exit because pedestrians are naturally attracted to these openings. Maximum lines of sight for both pedestrians and vehicles should be provided, and mirrors and warning devices should be incorporated when necessary. Access locations should be restricted to a few locations for security reasons.

A minimum of two stairs are required to meet code-required means of egress for fire exits in parking structures. Stairs shall be open or glass enclosed and be visible to the street for security reasons. The minimum stair width in parking structures is 44" and wider stairs are required for special events. Travel distance between exit stairs is specified in the IBC and is a maximum 300 feet without a sprinkler system and 400 feet with a sprinkler system. Stairs are usually placed in dead corners.

Elevators should be located at the facility terminus in the direction of pedestrian travel. Hydraulic elevators can be used for up to 5 levels or 50' to 60'. Traction elevators should be used beyond 5 levels. The minimum capacity and size is 3,500 lbs. and 5'-0" x 7'-0". The number of elevators is based on the number of spaces, the number of levels, user group(s) served, peak-hour flow rates, and the size and capacity of the elevator. A parking consultant can provide a preliminary indication of the number of elevators based on a formula that takes into account the information presented above. We highly recommend that elevators have glass backs for security reasons. Enclosed lobbies are recommended for protection from the elements on the top level.

15. Accessible Parking Requirements (ADA)

The following table presents the required number of accessible parking spaces based on the total number of spaces provided in any given facility.

Required Accessible Spaces	
Total Spaces in Facility	Minimum Accessible Spaces
1 to 25	1
26 to 50	2
51 to 75	3
76 to 100	4
101 to 150	5
151 to 200	6
201 to 300	7
301 to 400	8
401 to 500	9
501 to 1,000	2% of total
1,001 and over	20 plus 1 for each 100 over 1,000

The accessible parking requirement for an institution like a hospital campus is not based on the total parking capacity but rather on the capacities of the individual facilities within a parking system, which always results in the provision of more accessible spaces overall. Accessible spaces for the institution do not have to be provided in each parking area, but can be supplied at a different location provided at least equivalent accessibility in terms of distance, cost, and convenience is provided.

All accessible spaces are 8' wide with either a 5' or 8' access aisle. An accessible space and access aisle cannot be placed at a location with a running or cross slope greater than 1:50 (2%).

The current 1 to 8 ratio for the provision of van accessible spaces is changing to 1 to 6, and it is required to round up to the nearest whole number when determining the number of van spaces. The barrier free section of the International Building Code (IBC) has the same requirement. It is recommended to use the new 1 to 6 ratio when determining the number of van spaces. Van accessible spaces require minimum 8'-2" vertical clearance and have 8'-0" wide access aisles.

Each accessible space must have a sign showing the international symbol of accessibility mounted at least five feet above the pavement. All van accessible spaces must have an additional "Van Accessible" sign mounted below the symbol of accessibility (mount minimum of 5' above pavement with other sign above).

ADA requires rounding up to the next whole number when calculating the required number of spaces based on a percentage or ratio. For example, a parking facility with 810 spaces will have 17 accessible spaces (810 x .02 = 16.2 = 17 spaces), and 3 spaces will have to be van accessible (17 ÷ 6 = 2.833 = 3).

Accessible stalls cannot share access aisles when the parking is angled. Access aisles for van spaces must be on the passenger side when the parking is angled because vehicles cannot back into these spaces.

All accessible spaces must have an accessible route to public streets or sidewalks, accessible elevators, or accessible building entrances. An accessible route must have a minimum unobstructed width of 3'. A vehicle way (drive aisle) may be part of an accessible route, although it is preferred to place the accessible route at the front of the stalls. An accessible route can only pass behind other accessible spaces. It is permitted to cross a vehicle way with an accessible route. Automatic or push button door opening devices will be needed if the accessible path includes doors that patrons will need to enter/exit.

The running slope along an accessible route cannot exceed 1:20 (5%) and the cross slope cannot exceed 1:50 (2%).

It is recommended to cross hatch all access aisles and accessible routes.

Ultimately, accessible parking must be provided as required by existing city building and zoning codes. However, it is recommended that the standard ADA requirements detailed in this section be used if they exceed existing city requirements.

16. Safety and Security

Because curbs can be a potential tripping hazard, curbs in all pedestrian areas (at the end of parking rows, around stairs and elevators, dead corners, etc.) are strongly discouraged. The faces and edge of curbs that remain should be painted traffic yellow to enhance visibility.

Glass-backed elevators and glass enclosed and/or open stairways, visible to the adjacent street, are highly recommended for enhanced security. Security fencing should be installed below stairwells to eliminate the possibility of a person hiding under the stairs.

Lighting that enables users to see and be seen is one of the most important security features of a parking structure. A separate discussion on lighting is included in these guidelines.

Other important aspects of security design:

- Short span construction is not recommended. In short span construction, the columns are placed more closely together; thereby adding additional obstructions to lines of sight.
- Security fencing at the ground level should not be climbable. Security fencing ensures pedestrians enter/exit the facility only at designated pedestrian points.
- Landscaping should not provide hiding places.
- Security cameras are a deterrent to criminal activity.
- Panic alarms and two-way communication systems are recommended in prominent locations on each level.

In general, assure that as much openness as possible is provided in the design to improve sight lines, eliminate hiding places, and enhance perceived security.

17. Lighting

The following are key lighting considerations in parking facility design:

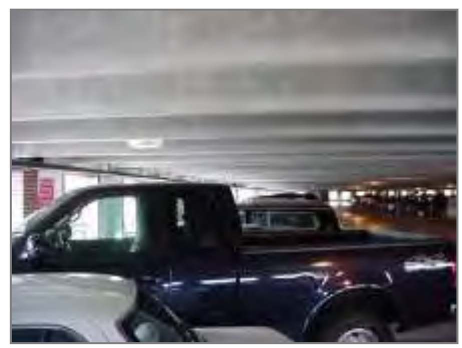
- Lighting is a key security measure
- Good lighting enhances user comfort & perception of safety
- Good lighting is a business attraction amenity
- Good lighting permits safe movement for pedestrians and vehicles
- Enhances signage visibility and readability
- Typically, light levels are not code regulated
    - Except emergency lighting @ 1 footcandles minimum
- Industry Standards
    - Illuminating Engineering Society of North America (IESNA)
    - IESNA publishes minimum lighting standards by building type
    - Liability risk for non-compliance

The recommended lighting standards listed in the table to the right, slightly exceed the Illuminating Engineering Society of North America (IES) lighting standards for parking facilities. Staining the ceilings and walls white to enhance light levels is suggested.

IES also recommends higher light levels at facility entry/exit points ("transitional lighting").

Recommended Parking Structure Lighting Standards

Areas	Minimum Horizontal Illuminance on Floor Footcandles	Minimum Vertical Illuminance at 5 feet Footcandles	Maximum to Minimum Uniformity Ratio
General Parking & Pedestrian	2	1	10:1
Ramps and Corners			
Days	2	1	10:1
Nights	1	0.5	10:1
Entrance Areas			
Days	50	25	10:1
Nights	1	0.5	10:1
Stairways	7 avg.		10:1



Lighting Entry and Exit Lanes

- Provide additional lighting (50 fc) for 10’-60’ zone from building edge (Transitional lighting)
- Include daylight infiltration (> 15 fc)
- Typically 10’ X 10’ spacing of 150 watt fixtures
- Turn 2/3 of fixtures off at night

Light Source Types

- High Pressure Sodium
    - Golden White HPS Light Color
    - Common Parking Structure Lighting
    - Lamp Life = 24,000-28,500 Hours
- Metal Halide
    - White Light Color
    - Perceived Greater Brightness
    - Lamp Life = 15,000 Hours
    - Operating Cost Slightly > HPS
- Light Emitting Diode (LED)
    - Emerging Technology
    - Energy Efficient
    - Long Life
- Fluorescent
    - White Light Color
    - New Technology – Use in Cold Climates
    - Cold Weather Ballast (If Temps < 50º F)

  - Phosphor Coating
  - Sealed Fixtures
  - Lamp Life = 30,000 Hours
  - Energy Cost Effective
- Induction Lighting
  - White Light – Best color rendition
  - Instant Ignition Long Life Bulbs = 100,000 Hours
  - Energy Efficient
  - High Initial Costs

Lighting Expense Reduction Strategies

We recommend that the exterior bay lighting of "open" parking structures as well as roof top lighting be on separate circuits so that these lights can be turned off during the day to reduce energy consumption/costs as depicted in the lower picture on the right.

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18. Signage and Wayfinding

Parking facilities can be very large, complex, and confusing. A well-designed graphics and signage system will effectively communicate necessary information to patrons, reduce confusion, improve safety, and enhance the overall user experience.

Sign messages should be simple and succinct. Messages on signs that are to be read quickly, such as vehicular signs, should be no more than 30 characters and six words in length. The typeface used should be simple and easy to read, and there is a general preference for Helvetica medium in the parking industry. Signs with lower case letters and initial caps are most easily read. The simple block arrow is recommended for parking signs. If a left turn is required, the arrow should be placed on the left side of the sign. The opposite is true for a right turn.

In parking structures, signs with a dark background and white letters are more easily read than signs with a white background and dark letters. The opposite is true in surface lots, where signs with white background and dark letters are better.

Vehicle Signs

Examples of vehicular signs include “Park” and “Exit” directional signs. Vehicular signs are ten or twelve inches in height with six or seven inch letters. Ten-inch signs are recommended for precast structures where sign visibility can be a problem. Vehicular signs should be centered over the drive lane or centered over the drive aisle when signs are mounted back-to-back.

Pedestrian Signs

Examples of pedestrian signs include "Level #," "Remember Level #," "Row #,"and "Stair" and "Elevator" identification and directional signs. Pedestrian signs can be all one color or be color-coded by level. Pedestrian signs should be clearly distinguishable from vehicle signs so as not to interfere with vehicular traffic. Pedestrian signs in parking bays are most effective if located perpendicular to traffic flow, and they should be placed at the rear of parking stalls. Color-coding is often used to help patrons find their vehicles. It is not necessary to provide color-coding in parking facilities that are three levels or less. When color coding, it is recommended to use primary and secondary colors including red, blue, yellow, orange, purple, and green. If there are more than six levels that need to be color-coded, it is recommended to use white, brown, and black. Confusing colors such as turquoise (blue or green?) and taupe (brown, tan, or gray?) should be avoided.

The elevator core area provides an excellent location to utilize super graphics. Super graphics is defined as a graphic that covers a large area and is generally painted on a vertical surface, such as painted walls or elevator doors, with level designation incorporated.

Once colors have been determined, the color coding must appear on each parking floor (e.g., on columns and walls) and adjacent to elevator lobbies and stairwells – as well as inside elevators.

Level Theming

"Level Identification Theming" and other wayfinding aids provides an opportunity to enhance parking interior environment enhancements while also providing a practical tools to assist patrons in remembering where they parked. Several creative examples or illustrated below.

Entry Signs

Emphasizing the entrance to a parking facility is important. Large illuminated signs are often used to emphasize the facility entry and attract patrons. These signs often spell out "Parking" or use the International symbol for parking. Architectural features, such as an arch, canopy, or some different treatment of the façade, are often used to highlight the entry area as well. A height clearance bar is required for all parking structures, including the top (surface) level of below-grade facilities to prohibit over-height vehicles. Generally, the height clearance bar is located at the facility entrance(s). There may be instances when the clear height in a parking structure changes from one level to another (for example, a higher ground level than typical level to accommodate ADA vans), which may require additional height clearance bars within the facility itself. Generally, the height clearance bar is an eight-inch PVC pipe.

Having internally or externally illuminated ENTRY and EXIT signage over entry/exit lanes is another recommended best practice.

Regulatory Signs

Regulatory signs are often used in parking facilities. Examples include "STOP," "YIELD," "ONE WAY," "NO PARKING" "DO NOT ENTER," and accessible parking signs. When used it is imperative that they comply with local and federal requirements. The Manual of Uniform Traffic Control Devices (MUTCD) provides examples of standard highway signs.

Illuminated Signs

Illuminated signs are becoming more and more common in parking facilities. Technology has advanced significantly in recent years and illuminated signs have become more reliable. Generally, illuminated signs are used for the following parking applications:

- Entry and Exit Lanes (Open in green/Closed in red)
- Facility Full Signs
- Stop (red)/Go (green)
- Level Space Capacity
- Directional Control
- Fee Display
- Space Count Systems
- Variable Message Signs

Pavement Markings

Pavement makings should conform to Manual of Uniform Traffic Control Devices (MUTCD) or local standards. MUTCD specifies that white paint be used for markings for traffic flow in the same direction and yellow paint used for traffic flow in opposite directions, which implies a warning.

Pavement markings can be an effective way to direct and control traffic flow in a parking facility. However, pavement markings must be re-applied due to wear and deterioration from vehicular traffic. Pavement arrows may enhance traffic flow. They are often utilized on surface lots or the top level of parking structures where overhead directional signage is not possible. Traffic arrows are also commonly used in facilities with a combination of one-way and two-way traffic flow.

19. Drainage

Proper floor drainage is essential for all types of parking structures in all climates. While direct rain or snow may not enter all areas of the parking garage, windblown rain and snow and/or vehicles carrying ice, snow and water will distribute water throughout the facility. Heavy rains will also overload top floor drains and water will run down the ramped floors to lower levels. In addition, the frequent floor wash-downs (e.g., washing the parking surfaces/floors) that should be part of a good maintenance program are a source of water throughout the parking facility. If the floor is not adequately sloped, water is allowed to pond and deterioration will accelerate beneath the ponds.

A design slope of 2%, or ¼ inch per foot, is desired, with a minimum design slope of 1-½%. Water should be drained away from exterior columns/walls and pedestrian paths. Washes may be needed in slab corners to achieve drainage slopes.

Floor drain locations are determined by the circulation system, number of bays, and structural system. The top level drain system should be designed to accept a 10-year design rainfall or as required by local code. Three to four inch piping is generally used on covered levels.

20. Open or Enclosed Parking Structure

Natural ventilation requires openings in exterior walls of sufficient size distributed in such a way that fresh air will enter the facility to disperse and displace contaminated air. The 2003 and 2006 International Building Code (IBC) states:

"For natural ventilation purposes, the exterior side of the structure shall have uniformly distributed openings on two or more sides. The area of such openings in exterior walls on a tier must be at least 20 percent of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall constitute a minimum of 40 percent of the perimeter of the tier. Interior walls shall be at least 20 percent open with uniformly distributed openings."

"Enclosed"

- **Enclosed Shafts**
- **Mechanical ventilation**
- **Increased illumination**
- **Increased fire rating**
- **Fire sprinklers**

"Open"

- **"Open" structures are allowed much larger floor plates and many more levels**
- **"Open" structures are naturally ventilated, so do not usually need mechanical ventilation**
- **"Open" structures do not require stairs to be enclosed**
- **"Open" structures allow a lot of natural light**

"Exception: Openings are not required to be distributed over 40 percent of the building perimeter where the required openings are uniformly distributed over two opposing sides of the building."

Setbacks can affect openness as firewalls are required if certain distance requirements from property lines and other buildings are not maintained. Parking structures are typically classified as enclosed if other uses (retail, office, residential) are located above the parking, but may remain open if parking is above or adjacent other uses. When a parking structure is positioned below grade, areaways can be used to achieve natural ventilation. The building code addresses the geometry required to permit acceptance of an areaway.

Parking structures classified as "open" do not require mechanical ventilation, fire suppression (sprinklers), and enclosed stairs.

21. Structural Systems

Following are the advantages and disadvantages of the three primary structural systems commonly used in parking structures today:

- Cast-in-Place Concrete
- Precast Concrete
- Steel Framed

The selection of the structural system should be given careful consideration. The decision is often made based on the following:

- Owner preference
- Design team preference
- Development Review Agency (or Agencies) input
- Schedule
- Construction budget
- Openness and perceived headroom
- Owner's tolerance and budget for maintenance
- Local availability of product and labor

Cast-in-Place Concrete

Advantages of Cast-in-Place Construction:

- Monolithic construction so fewer sealant joints
- Positive drainage is easier to achieve
- Post-Tensioning forces reduces slab cracking
- Floor vibration imperceptible
- Flexible column spacing (20' to 27')
- Generally no shear walls
- Lower maintenance cost
- Wide beam spacing creates more open feeling with perception of higher ceiling
- Accommodates parking structures on irregular sites, beneath buildings, and underground

Disadvantages of Cast-in-Place Construction:

- Potentially higher construction cost
- Quality control is more difficult to attain due to exposed weather conditions
- May require architectural cladding to improve exterior aesthetics
- Less adaptable to winter construction in cold climates
- Longer on-site construction schedule
- Closer expansion joint spacing
- Congestion of tendons and rebar at beam column joints
- Larger on-site staging requirement

Precast Concrete

Advantages of Pre-Cast Construction:

- Quality control because members are fabricated at a plant
- Potentially lower construction cost in some regions
- Shorter on-site construction schedule
- Greater expansion joint spacing (up to 300 feet)
- More adaptable to winter construction
- Architectural façade spandrels also serve as structural load bearing elements

Disadvantages of Pre-Cast Construction:

- More propensity for leaking at the joints
- Higher maintenance cost for sealants
- The close spacing of thee tee stems creates the perception of lower ceiling height
- Garage structural "tee stems" can block signage and interfere with lighting distribution
- Shear walls affect architecture at the exterior and reduce visibility at the interior
- Reduced drainage slopes
- More bird roosting ledges
- Might not be performed by local subcontractors

Steel Framed

Advantages of Steel Construction:

- Flexible column spacing of 18' to 22'
- Generally no shear walls
- Can be performed by local subcontractors
- Shorter on-site construction schedule
- Potentially lower construction cost
- Easily accommodates vertical expansion

Disadvantages of Steel Construction:

- Erection concerns due to mixing foundation, steel, and precast subcontractors
- Not recommended where the steel is required to be fire rated by the building code
- Depending upon code requirements, steel structure may need to be fireproofed
- Steel painting for corrosion protection
- Maintenance of steel paint system
- Steel delivery times can fluctuate
- Extensive bird roosting ledges on the beam flanges

22. Durability Design

It is recommended to perform an analysis in the schematic design phase to determine which durability elements should be included in the design of a parking structure. These elements include sealers, deck coatings, concrete additives, corrosion inhibitors, and epoxy coated reinforcement. Durable parking structures also require quality concrete (low water-to-cement ratio), adequate concrete cover, proper concrete curing, and good drainage. Tradeoffs between initial costs and long-term maintenance costs should be considered. Enhanced durability systems should be provided in areas with severe exposure, such as supported structure near vehicular entries and snow storage areas on the roof level. Deck coatings (membrane) are recommended over occupied space and over electrical and storage rooms.

The design of a parking structure should at a minimum conform to the intent of American Concrete Institute's Guide for the Design of Durable Parking Structures (ACI 362). The design life of a parking structure should be 60 years.

23. Incorporating Other Land Uses

Many cities today are encouraging or requiring the design of parking structures that enhance the urban environment. Design Guidelines have been established that require parking structures to have level façades on the street sides (no exposed ramps) and pedestrian-active uses on the ground level. Even if not required by local code, there has definitely been a trend away in recent years from stand-alone, single-purpose parking structures. The development of ground-floor retail space in parking structures is often encouraged as even second-rate retail space will typically generate more income per square foot than a good parking space. This is an important consideration as most new parking structures are not self supporting. When selecting a site for the development of a parking structure, the site that offers the best possibility for ground-floor retail space should be an important consideration.

- New parking structures should incorporate other land uses (e.g., first level commercial space or commercial/residential space wrapping one or more sides) whenever physically/financially possible.
- First level commercial space will increase first level floor-to-floor heights and may necessitate adjustments to the structure's ramping scheme (e.g., inclusion of non-parkable speed ramps).
- Designs should minimize the impact of commercial space on the first level circulation system.
- Designs may need to consider loading dock space and garbage space in the parking structure.
- Restaurant space will need adequate ventilation, which may impact parking efficiency on the levels above the space.

- Entry/exit locations should be adequately positioned to account for adjacent traffic patterns and roadway conditions. Entry/exits should provide for easy identification and access from adjacent streets.
- Parking demand for the integrated commercial/residential land uses should be included in the parking supply and demand analysis for the structure.
- If there is no current market for additional commercial space, the parking facility could be designed to accommodate additional land uses in the future when market conditions warrant.

24. Other Considerations

There are other aspects of parking structure design that will not be specifically addressed but should be kept in mind, including:

- Zoning Requirements (permitted uses, setbacks, easements, etc.)
- Building Code Compliance
- Subsurface Conditions and Foundations
- Aesthetics
- Fire Rating, Fire Protection and Life Safety
- Mechanical Systems
- Storm Drainage and Water Storage
- Parking Access and Revenue Control Equipment
- Impact of Mixed Uses (retail, residential and office)
- Parking Office Requirements
- Maintenance

25. Sustainable Parking Operations and Management

This chapter identifies the many areas that can be addressed when a program wishes to enhance the sustainability of their parking operations program. Ideas are presented for the parking operator or owner to consider, whether the parking system includes one or multiple facilities, and whether it is an established system or a new one.

In the introduction to the Green Parking Garage Certification manual it is noted that "as an asset class and building type, historically parking has lagged in the sustainability movement. Yet, parking and mixed-use structures constitute a substantial portion of the built environment. Additionally, parking and transportation have significant environmental impacts, especially regarding carbon emissions, pollution, and fuel consumption."

Parking sits at the critical intersection of the built environment and transportation modes. As such, parking structures create new opportunities to advance sustainability – both in how we plan, design, and maintain parking structures (the built environment) and our commuting and travel options (transportation modes).

Note: A more comprehensive discussion of these concepts as well as a structured approach to developing a parking operations and management program that is designed to meet specific sustainability goals can be found in the book "The Sustainability of Parking" jointly published by the International Parking Institute and the National Parking Association. (See CHAPTER 5, Sustainable Parking Operations and Management.)

It should be noted that, while this chapter references programs geared toward reducing greenhouse gasses and other climate change related issues, carbon emission reductions are necessarily the ultimate goal, but are one example of "measurable outcomes" if your program has adopted a climate change based philosophy. Many other ways to quantify sustainable parking and transportation program impacts exist and more are being developed as these programs evolve.

26. Sustainable Parking Operation and Management Checklist

The following check list of sustainable parking and transportation demand management strategies was developed after reviewing several current texts on this topic as well as reviewing programs such as LEED, Green Globes and the Green Parking Council. This checklist provides a wide range of options in a number of categories designed to promote:

- Increased energy efficiency and performance
- Reduced environmental impact
- Efficient parking space management
- Integrated sustainable mobility services and technologies
- Enhanced performance as mobility hub
- Stronger community relationships

The Green Parking Council uses a standard that is organized into four major categories: Management. Programming Technology/Structure Design and Innovations.

- Management highlights ways in which garage operations can maximize the use of a parking asset while minimizing waste. Embracing these practices ensures facility staff utilizes resources to their full potential.
- Programming guides garages to new revenue sources, greater customer satisfaction and stronger community relations. Green garage programs ensure effective vehicle ingress/egress, provide access to alternative mobility solutions, and leverage the garage's potential as a public space.
- Technology and Structure Design outlines the physical attributes a garage can deploy to increase energy efficiency, lower waste and support customer mobility choice.
- Innovations focuses on emerging sustainability initiatives and concepts that while not yet in the mainstream usage provide creative ideas and inspiration for potential future adoption.

The Sustainable Parking Operation and Management Checklist is organized into the following categories:

1. **Planning**
2. **Parking Management**

3. **Facility Design/Layout**
4. **Demand Reduction / Transportation Demand Management (TDM)**
5. **Alternative Transportation Support Programs**
6. **Wayfinding and Parking Guidance**
7. **Use of Recyclables**
8. **Energy Savings/Generation Strategies**
9. **Water Management**
10. **Facility Maintenance and Cleaning**
11. **Electric Vehicle Charging**
12. **Green Garages**

1. Planning

- Integrated Parking and Transportation Planning
    - Develop a parking strategic plan in conjunction with a larger community-wide transportation plan
- Parking Requirements or Guidelines
    - Ensure parking requirements or guidelines (where exempt) are appropriate and "right-sized" for the environment
- Flexible Zoning Code Standards
    - Adopt flexible zoning code standards that take multiple factors into account
- Environment Specific Parking Ratios
    - Develop a parking space-to-gross square foot (GSF) ratio goal that reflects "essential need"
    - Use the target ratio in parking planning appropriate for the environment
- Shared Parking
    - Promote shared parking whenever possible

- Utilize the ULI "Shared Parking Model" to promote the "rightsizing" of parking development (taking advantage of complementary peak parking accumulation patterns by certain combinations of land-uses when the parking resources can be effectively shared).
- Encourage and design parking facilities to support shared parking.

- Parking Location Planning
    - Consider providing public parking in locations that strategically supports an area or district.
    - Plan for some additional public supply when a new development is created to anticipate adaptive reuse and in-fill projects in the area
    - Strategically consider the proximity of parking facilities to transit resources to promote a "Park Once" environment.
- Life Cycle Cost Assessment
    - Conducting a life cycle cost assessment especially of durability design elements, may increase initial facility development costs, but can provide significant savings in terms of long-term life cycle costs for a parking facility.

2. Parking Management

- Charge for Parking
    - Charging market rates for parking makes the public aware of the fact that parking is never free and promotes consideration of alternatives.
    - Implement "Demand-Based Parking Pricing" strategies.
    - Coordinate on and off-street parking rates:
        - Set pricing for on-street parking to promote short-term, high turnover parking
        - Set off-street pricing to encourage longer-term parking
- Develop a parking allocation program based on "essential need".

  - The way we allocate our resources gets to heart of a parking program's philosophy and core principles. If sustainability is considered a core value, then decisions related to parking resource allocation should reflect sustainability principles. For example, at the Seattle Children's Hospital, all parking is provided only on a daily fee basis (monthly parking charges were eliminated). With no sunk costs related to monthly parking passes, other commute options are encouraged.
  - Develop parking policies designed to meet the needs of multiple parking patron types (i.e. commercial, retail, residential, etc.)
- Reserved Parking Areas
  - In general, the use of "reserved parking" is discouraged in that it promotes inefficiency in utilizing available resources and limits the ability to share and over-sell spaces
  - Implement or expand reserved areas for car/vanpools
  - Implement or expand reserved areas for hybrid/low emission vehicles
- Discounted Parking Rates and special offers
  - Offer "Clean Air Car Discounts" or "Green Parking Permits" (i.e., reduced parking rates) for car/vanpools
  - Offer "Clean Air Car Discounts" or "Green Parking Permits" (i.e., reduced parking rates) for hybrid/low emission vehicles
- Technology
  - Help drivers exit the garage with little or no idle time with traffic control (i.e. pay-on-foot kiosks, automatic vehicle identification (AVI) technology, etc.)
  - Evaluate space availability systems to reduce the search time for spaces within parking facilities
- Special Programs / Events
  - Participate in annual events such as "Parking Day" to promote awareness of program alternatives
  - Offer tire inflation stations to encourage proper tire pressure which can contribute to increased fuel economy

- Work with local TMAs or Transit Agencies to develop and promote "Transportation Fairs" or other community-based programs to educate and encourage the use of transportation alternatives

3. Facility Design/Layout

- Facility Design
    - Consider "Green Roofs" (vegetation), "Blue Roofs" (retains water), or "Cool Roofs" (roof coated with a light colored, solar reflective materials)
- Facility Lighting
    - Light with energy-efficient fixtures / Reevaluate lighting types (consider replacement with LED or fluorescent lights to reduce power usage)
    - Develop a fluorescent lamp recycling program
    - Stain or paint interior parking garage surfaces to maximize reflectivity and enhance facility lighting without increasing energy costs
    - Consider the use of sensors/timers to reduce light levels in certain zones when not in use, or during daylight hours
    - Evaluate individually powered solar parking lot lights
- Parking Layout
    - Assess current parking space layouts, and consider options to maximize use of existing spaces

4. Demand Reduction / Transportation Demand Management (TDM)

- Evaluate changes to parking pricing that could reduce parking demand
    - Belong to an organized Transportation Management Association
    - Provide easy access to alternatives
    - Consider restricting parking availability

- Offer discounted transit passes and sell them along with parking permits
- Develop a "commute options" program to make patrons more aware of the alternatives to driving alone
- Offer a "parking Cash-Out" option
    - Commute bonus for alternative commute—up to $65/month (pre-tax deduction)
- Develop an on-line commute management system that allows employees to claim commute bonus, track parking charges and plan alternative commute trips and find carpool/vanpool partners.
- Offer an option to the traditional "monthly parking contract" – Consider offering a "Parking Scratch-off Card"
    - "Unbundle" monthly parking by offering a punch card option instead of a traditional access card
    - Drivers only pay for days they drive
    - Creates an incentive to consider alternatives to driving

- Support Active Transportation Program Development
    - Promote zero-impact modes of travel
    - Add or expand secured parking facilities for bikes
    - Company bike or a free bike for an employee who commits to bike to work at least 2 days/week
    - Implement a program of providing temporary bike racks to handle seasonal demand peaks for bike parking. The temporary bike rack pictured to the right takes up only one on-street parking spaces
    - Implement or participate in promoting a bike-share program
    - Offer parking for bicycles
    - Offer bike sharing (or have one nearby)
- Marketing and Communications
    - Improve marketing of transportation alternatives

  - Improve TDM marketing outreach to include direct participation in all new student and employee orientations
  - Solicit and convey vanpool and bus club customer testimonials about their positive experiences as members
  - Solicit/Expand transportation department's participation in the larger community "Sustainability Committees" or "Transportation Master Planning processes"
  - Promote an increase in funding for pretax transit and downtown shuttle programs
  - Generate/Expand car-sharing program participation through user-based promotional efforts

- Fleet Management
  - Reduce campus fleet vehicles' reliance on fossil fuels
  - Increase percentage of "alternative fuel" vehicles in fleet
  - Expand car-share fleet to meet daily vehicle trip demand of departments, employees, and students
  - Integrate campus or corporate fleet management with carsharing programs providing faculty, staff, and students with instant access to a fleet of vehicles within walking distance from campus or downtown offices
  - Offer reserved or discounted parking for vanpool or carpool customers
  - Provide reserved or discounted parking for fuel efficient vehicles
  - Provide reserved or discounted parking for alternative fuel vehicles

5. Alternative Transportation Support Programs

- Provide or support a range of transport alternatives
  - Increase the amount and types of bike parking
  - Become a funding partner for campus or community bike rental programs

- Invest in changing rooms/showers
- Partner with bike concierge services
- Provide reduced priced parking in remote "ride sharing" collector lots, supported by transit of shuttle programs

6. Wayfinding and Parking Guidance

- Improve parking signage and information
  - Help drivers find your parking facility more easily with enhanced signage and wayfinding outside of your garage
  - Consider incorporating parking availability data into external and internal parking signage
  - Help patrons locate available spaces more quickly and efficiently with internal wayfinding
  - Evaluate or implement parking guidance systems to improve parking efficiency
  - Develop a parking availability/location mobile device application to reduce the circling of vehicles

7. Use of Recyclables

- Recyclable Resources
  - Replace all light bulbs in office environments with compact fluorescent bulbs
  - Replace concrete parking and traffic products with those made from 100% recycled rubber (e.g., wheel stops, speed humps, sign bases, etc.)
  - Implement a parking garage lighting recycling program (especially if fluorescent lighting fixtures are in use.)
  - Offer recycle bins for patrons & employees
  - Purchase recycled, organic or local products

  - Recycle disposed materials, use local labor, or source local or recycled materials when undergoing new construction or renovations

8. Energy Saving/Generation Strategies

- Energy Related Strategies
  - Have climate controlled occupied areas (programmable thermostats/sensor controls)
  - Have an open air design with no ventilation system in the parking areas
  - Ventilate the decks with variable controlled air flow (i.e. VFD) or sensor activated (i.e. DCV) technology
  - Generate renewable energy (i.e. solar PV, wind turbines, hydroelectric)
  - Cover parking lots and garage roofs with solar panels.
  - Generate renewable energy strategies (i.e. solar PV, wind turbines, etc.)

9. Water Management

- Water Saving
  - Replace plumbing fixtures with water-saving fixtures
  - Use water-efficient landscaping (e.g., xeriscaping/native plants to reduce irrigation needs)
  - Develop a storm water management plan
  - Capture "grey water" for use in watering parking landscaped areas

10. Facility Maintenance and Cleaning

- Maintenance, Recycling and Environment Enhancements
  - Implement on-site wastewater treatment

    - Use sustainable cleaning supplies/Clean with green, non-toxic cleaning products
    - Apply low- or no- VOC (Volatile Organic Compound) coatings to all surfaces
    - Make interior spaces tobacco free
    - Add recycling containers for all facilities where they are convenient to patrons and staff

11. Electric Vehicle Charging

- Promote the use of non or reduced emission vehicles
    - Provide charging stations for electric vehicles
    - Develop electric vehicle charging system specifications

12. Green Garages

- Consider third party sustainability certifications, such as LEED or Green Globes
- Adopt a standard that all parking construction will seek a LEED ®-based equivalency rating of "Silver" or better when feasible and/or Green Parking Council standards.
- Adopt a standard for new garage development that solar arrays that generate up to 50% of the facility's power needs must be integrated

Appendix 6

City of Rochester

Current Parking Development Scenarios

Report Version: 1.0

Prepared for:

DMC Transportation & Infrastructure Program
City of Rochester, MN

Prepared by:

Date: 12/20/2016

DMC Project No. Rochester J8618-J8622 Parking/TMA Study

Table of Contents

File Name: Rochester J8618-J8622 Parking/TMA Study_Task_Current Parking Development Scenarios.docx

Current City of Rochester Parking Development Scenarios

1. Introduction

Currently, several private redevelopment projects in the downtown area are being considered by the City of Rochester and the Destination Medical Center (DMC) board. Parking is a critical component of these projects. All projects are requesting public assistance to help offset the cost of parking. Each of the projects intend to start construction in 2017 or 2018.

The purpose of this paper is to address the parking impact of these projects and set forth a plan to satisfy future parking needs without creating an undue burden on the existing parking system. This paper is intended to initiate a discussion about parking policy and allocation of public resources to satisfy parking needs for these types of situations now and into the future.

2. Projects under Consideration

The three projects in the downtown area that will impact parking are the Bloom Project, the Michael's Project and the Broadway and Center Project (See Exhibit 1). Two of the projects call for the removal of existing parking structures, containing nearly 1,000 spaces, before new parking can be developed. Parking in the downtown area is already in short supply and the elimination of parking during construction is a serious problem.


EXHIBIT 1
Development Projects
Downtown Rochester
Minnesota
November, 2016
Michaels Project
Broadway at
Center
Center Street
Bloom
Development
2nd Street
Broadway
3rd Ave

In general, the future parking associated with each project falls into one of two categories: parking dedicated to the proposed development needs and parking for public use. Because each project is currently being negotiated, assumptions about parking allocations were made and will likely need to be adjusted as more information becomes available and the current effort to evaluate parking throughout the DMC area continues to take shape with development of a dynamic parking supply and demand model.

Broadway and Center Project

The Broadway and Center project is likely the first of the three projects to begin construction in 2017. Tax increment financing will help pay for the adjacent 600 to 700 space parking structure. Some of the spaces will be dedicated for the exclusive use of the project. For the purposes of this analysis we assume that 300 spaces are available to the public. The parking ramp is being built on an existing public surface parking lot so those spaces will be lost during construction and ultimately replaced by the parking structure.

Bloom Project

The Bloom project is a large mixed use project that is scheduled to start construction in 2017. Per the developer, the project will be developed in two phases with a construction period of approximately three years. The first phase will be developed between Third Street and Fourth Street. The second phase will be developed from the north end of phase one and will extend to Second Street. Phase 2 will require the removal of the Second Street Ramp. Per the architect, the project, as currently proposed, contains 714 parking spaces of which 364 will ultimately be available for public use. 100 public spaces will be available in phase one and 264 spaces will be available in phase 2. The architect went on to say that the parking in the proposed development is very inefficient due to the geometry of the site (500 to 600 sf /space). A typical parking ramp has an efficiency of 350 sf / space.

Michael's Project

The Michael's project is a large mixed-use project located on the site of the former Michael's restaurant that is scheduled to start construction in 2017. The project requires the demolition of the Center Street parking structure before construction can commence. As of this writing no drawings have been submitted to the City that indicate how much parking will be provided with the project. This preliminary analysis will assume that 200 public spaces will be incorporated in the project in addition to parking required for the project.

3. Analysis of Parking Supply

Table 1, below, describes the municipal parking supply by quarter for the next four years assuming the three projects described above proceed as planned. The city currently owns and operates approximately 5,348 public parking spaces in the core area along with several park and ride facilities located in various locations around the city. The proposed developments will result in the removal of the 2nd Street Ramp and the Center Street Ramp. In addition, the table also reflects the addition of public parking based on the assumptions and information provided above. The table also includes the addition of a 1,000 space parking ramp to compensate for the loss of parking and increased demand. Among other things the table calculates that the existing public parking supply will be reduced during construction periods by 10% in early 2018.

Analysis of Near Term Parking Supply
11/30/16

Rochester Parking System	Existing	2017				2018				2019				2020			
Ramps		1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th	1st	2nd	3rd	4th
1st Street Ramp	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578	578
2nd Street Ramp	435	435	435	435	435	435	435	435	435	0	0	0	0	0	0	0	0
3rd Street Ramp	925	925	925	925	925	925	925	925	925	925	925	925	925	925	925	925	925
Center Street Ramp	393	393	393	393	0	0	0	0	0	0	0	0	0	0	0	0	0
Civic Center Ramp	642	642	642	642	642	642	642	642	642	642	642	642	642	642	642	642	642
[illegible]	0	0	0	0	0	[illegible]	[illegible]	[illegible]	700	700	700	700	700	700	700	700	700
[illegible]	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	200	200	200	200	200	200
[illegible]	0	0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	364
New Parking Garage							1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
Surface Lot																	
First Avenue Lot	82	82	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Zumbro Market Lot	65	65	65	65	0	0	0	0	0	0	0	0	0	0	0	0	0
Civic Center North Lot	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193	193
Mayo Ballfield Lot	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135	135
Civic Center South Lot	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330	330
Government Center Lot	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144	144
Government Center South Lot	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
Civic North Overflow Lot (Power Plant)	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76	76
Meters																	
On-Street Meters	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257	1,257
On-Street Meters (Saint Mary's)	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27	27
Total	**5,348**	**5,348**	**5,266**	**5,266**	**4,808**	**5,508**	**6,508**	**6,508**	**[illegible]**	**6,173**	**6,173**	**6,373**	**6,373**	**6,373**	**6,373**	**6,373**	**6,637**
Percent of Existing Parking	**100%**	**100%**	**98%**	**98%**	**90%**	**103%**	**122%**	**122%**	**121%**	**115%**	**115%**	**119%**	**119%**	**119%**	**119%**	**119%**	**124%**

Construction Period

Michael's Project	
Broadway & Center Project	
Bloom Project	

Kimley»Horn

SRF Consulting Group, Inc.

4. Public Policy Issues

Traditionally, financing of parking for downtown redevelopment projects in Rochester has been in large part provided through tax increment financing. The City also has a Parking Enterprise Fund that receives revenue and pays costs associated with the public parking system. Because tax increment financing has been the dominant source of revenue to pay for major parking, expansion projects have tended to be project specific even though a portion of each parking structure is available to the public. The Center Street Ramp, for example, was funded in the late 70's from tax increments generated by the Norwest Bank (now Wells Fargo). Without this assistance, the redevelopment project would probably not have occurred. This project specific approach to financing parking is a common approach across the country.

Among other things, the DMC Master Plan calls for reducing the number of automobiles per person in the downtown area by building remote park and ride facilities on the periphery of downtown. These parking facilities would be designed to attract employee parkers who currently park in the core area. This approach to parking requires a different approach to financing parking, one that is not as coupled to redevelopment projects.

5. Decoupling Parking from Individual Development Proposals

On November 10 Kimley-Horn met with representatives of Rochester Public Works and the City Administration. At that meeting, the concept of proceeding with bidding Ramp No. 6 and sizing and site selection of Ramp 7 was discussed. Various locations outside of the Central Business District were discussed for Ramp No. 7 including the Mayo Fullerton Park and Ride, the Ballpark Site and a site north of Mayo Civic Auditorium. The financing concept discussed to decouple parking from development was to use a combination of existing revenue and cash flow from the parking enterprise fund to finance two parking structures. Tax increments from future projects and other sources would be used to replenish the parking enterprise fund.

The advantages of this approach are:

1. Projected near term parking deficits could be mitigated.
2. Parking could be planned more intentionally to serve multiple development and forward DMC urban design goals
3. The cost of parking could be reduced by the selection of sites more conducive to efficient parking.

Appendix 7

Employee Parking & Commute Option Programs and

Strategies to Maximizing Existing Parking Resources

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Prepared for:

DMC Transportation & Infrastructure Program
City of Rochester, MN

Prepared by:

Date: 10/25/2017

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1 INTRODUCTION

Developing a Comprehensive Approach to Employee Parking and Commute Option Programs

"Every day 130 million people commute to worksites across the nation, from large downtown office buildings to suburban office parks, and every location in between. Employees face increasing challenges getting to work in the most efficient, affordable and sustainable way – a challenge that can negatively impact productivity if not addressed. Progressive employers understand the steps available to improve the commute options for their workforce can have wide ranging benefits including:

- Attracting and retaining employees
- Improving work life balance
- Achieving corporate sustainability and climate goals
- Reducing transportation costs and tax savings"[1]

The quote above comes from a paper published by the Association for Commuter Transportation entitled "Getting to Work – Spotlight on employer-sponsored commuter programs". This paper is just one resource provided as an appendix to this whitepaper that focuses on the development of a comprehensive approach to employee parking as well as providing a range of alternatives including creative commuter options.

This whitepaper (Employee Parking & Commute Option Programs) begins by discussing "Why Parking Matters" and the many impacts parking can have on communities, employers and employees, including such elements as "the myth of free parking", economic considerations, costs associated with land use, transportation costs, sustainability issues and direct and indirect costs. It then documents research on effective employer parking programs, policies and best practices and then broadens its scope to explore a wide range of commute option programs that have been proven effective in mitigating employee parking demand and providing a range of transportation alternatives and employee transportation benefits.

2 WHY PARKING MATTERS

The design and availability of parking has the potential to shape both the look and feel of a city, the quality of life of its citizens and visitors, and the potential for new growth and development. The need to accommodate parking must be balanced with other competing goals for the built environment such as livability and economic development. It is important to acknowledge that it is impossible to accommodate the land consumption that would be required to park every

[1] "Getting to Work – Spotlight on employer-sponsored commuter programs" Taking ACTion – January 2017, Association for Commuter Transportation

vehicle since it would prevent the City from achieving its goals of being a sustainable, livable community.[2]

PARKING:

- Impacts the look and feel of a city and its neighborhoods
- Is shaped across multiple levels of policy, regulation and administration
- Is an important component of the overall land use and transportation system
- Can affect traffic congestion
- Has cost and value associated with every space
- Is dynamic and varies based on the surrounding land use and time of day
- Is part of a larger city system with many stakeholders
- May require tradeoffs in our behavior, expectations, and choices
- Demand is most intense where there are centers of activity, mixes of land uses, and where land is valuable
- Takes up land as one off -street space = 300+ square feet of physical space.
- Structures cost upwards of $18,000 - $30,000 per space.
- Affects housing affordability
- Can contribute to urban sprawl and pollution

EVERYONE PAYS FOR PARKING

Whether it is through a direct or indirect charge or an impact, parking is never free. Even in situations where parking appears to be free, like at grocery stores or shopping centers, the real costs of parking are often hidden. Businesses that provide free parking might fund the cost of providing parking through their annual operating budgets. Other businesses might even pass on those costs through the price of their goods or services. Likewise, the parking spot on the street in front of a home has a cost that is paid for by tax receipts.

The cost of parking, however, is more than just physical. The opportunity costs associated show that parking is worth much more than the amount of quarters it takes to plug a meter. Its value is evident in terms of economic development, land use, the health and connectivity of the overall transportation system, and environmental sustainability.

ECONOMIC DEVELOPMENT COSTS

Effective parking policies and management strategies directly impact local economic development. Parking supply is often a key consideration for businesses considering any City as a location since they must consider access for both employees and customers. Customers think about parking as they make decisions regarding where to shop, do business, and play. Customers

[2] Excerpt from the Denver Parking Strategic Plan, October 2010

may choose to go elsewhere If the parking associated with a business or commercial area is limited, perceived as too far away, is too expensive, or is inconvenient.

The Urban Land Institute document, “Ten Principles for Rebuilding Neighborhood Retail (2004)”, encourages balancing a walkable environment with convenient access in urban shopping locations. It advocates for “high visibility, a sense of personal security, and adequate convenient parking” as necessities for successful retail but warns that “without them retail will likely fail, regardless of the sophistication of the shopping environment or the quality of the tenants”. The parking decisions made by the affected stakeholders and their economic impacts are important since it relies on tax revenues from retail sales to fund city services for both residents and businesses. In some cases, there is a relationship between the provision of parking and economic vitality. The goal is to achieve what is often a delicate balance between local area interests and overall city and community interests to create lively, attractive, and sustainable places.

COSTS ASSOCIATED WITH LAND USE AND NEIGHBORHOODS

In a typical North American city, the amount of space dedicated to roadways accounts for about 30% of the total land use. Land used specifically for parking simply adds to the overall percentage of space that is dedicated primarily to automobiles.

In addition, the visual impact of too much surface parking in an area can be striking. If the supply of surface parking is underutilized, it may also be perceived as unsafe or may not attract new development. The decision to use large areas for surface parking in urban areas where land values are high may not be the most cost-effective or efficient use of land for both individual community and city interests.

Finally, parking requirements for new development may significantly impact construction costs and impact the financial feasibility of a project. Many communities are poised to invite new development of many shapes and sizes. This growth will contribute much to the vitality of different neighborhoods as well as the communities. Future land choices should support the City’s goals of providing affordable housing choices, increased services, jobs, and neighborhood retail.

TRANSPORTATION COSTS

Parking is an important component of the overall transportation and mobility network since the design and location of parking can influence personal travel choices. If there is a reasonable chance of free and available parking at one’s destination, it is more likely that an individual will choose a private automobile for the trip. Free and abundant parking provides no incentive to utilize alternative forms of transportation; prioritizing the use of personal vehicles over walking, cycling, or transit use. In addition, the location of parking can directly impact safety, circulation, and access for users of other transportation modes. The use of on-street parking should be weighed against other potential uses of available right-of-way such as bike lanes or dedicated transit lanes. While congestion and air pollution levels increase with additional vehicles on the road, decreasing the number of vehicles on the road could reduce parking demand, traffic congestion, and pollution levels.

ENVIRONMENTAL SUSTAINABILITY COSTS

The quality of a community's environment is impacted when land is dedicated to parking uses. Large surface parking lots can contribute to the "heat island effect" when asphalt absorbs and retains heat from the sunlight. Additionally, ground covered with asphalt or concrete is impermeable, which inhibits natural drainage and can carry run-off water containing oil, gas, grease or other fluids into storm drains, rivers, or streams. This ultimately impacts the City's overall water quality. Land dedicated to cars for roadways or parking should instead be balanced with opportunities for green spaces where plants and trees help improve air and water quality.

DIRECT COSTS

Parking requires substantial capital and operating expenditures that are not always recovered from those who use the spaces. Cities, corporate campuses and other large institutions routinely manage hundreds of on and off -street parking spaces, however, only a very small fraction of those spaces typically produce revenue. Each space has an associated cost in terms of land value, maintenance, utility and management expenses.

Land utilized for on-street parking is a scarce and highly valuable resource. Effectively managing on-street parking primarily as a short-term, high turn-over resource is highly recommended. It is costly to build additional parking even if it is developed as surface lot parking. It is especially expensive when it requires the construction of underground or raised structures. In addition, each space must be maintained to make sure it is safe, accessible, and complies with zoning requirements or other city standards. Successful parking systems also require constant monitoring and administrative management to make sure that they are meeting the needs of users and citywide goals. Parking studies, data collection, and other evaluation strategies are costly and time consuming but are often necessary to calibrate the usefulness of the overall system.

Active parking management has a significant cost impact for municipalities. Many cities devote full-time staff teams to the management of parking operations and enforcement. Enforcement teams that monitor parking management compliance require personnel and equipment resources. Parking technologies that improve customer service and performance for users, such as online citation payment websites or the installation of new, more convenient meter technologies also represent significant capital investments for the City. Finally, the maintenance of on- and off-street parking facilities includes costs such as resurfacing concrete and asphalt, striping, and signage to ensure that parking spaces are functional and clearly marked. Although meters and enforcement activities can generate citation or fine revenue for the City, expenditures to keep parking inventory and programs running effectively often cut deeply into any profits.

The bottom line is that parking is an essential element of modern society and its impacts and cost are not insignificant. However, an effectively managed parking system can also contribute greatly to health, vitality and image of any community or campus; and within the realm of parking management, one of the biggest elements of an effectively managed system is the development of effective strategies and policies to address employee parking. In this context, employee parking can mean either managing your own employees, or in a broader context, having a range of options to address the needs of employees areas where parking is managed.

3 EMPLOYEE PARKING PROGRAM RESEARCH

Because accommodating parking for employees/commuters accounts for such a large percentage of parking needs for any community, and because employers can offer their employees alternatives to driving single occupant vehicles, interest in exploring the range of strategies employed by parking management organizations in a variety of parking environments is high. Combine this with the often-significant cost of providing parking, recent surges in advanced transportation demand management solutions (largely driven by technology and mobile communications) as well as the emergence of a new topic area being referred to as "Shared Mobility", and it is easy to understand why this topic area is currently receiving a lot of attention.

As part of the research for this project, Kimley-Horn reached out to several of the top parking management professionals across the country to get their input relative to the issues associated with developing and implementing effective employee parking programs. Below is summary of the feedback we received.

INSIGHTS FROM ACTIVE PARKING MANAGEMENT PROFESSIONALS

City of Beverly Hills, CA

Topic: Valet Stack / Tandem Parking Options:

- Although no one likes to leave their keys, in our experience, 'monthly' users (employees) that use valet stack / tandem parking daily have more issues; claims, complaints, etc. than occasional customers. To address, we have done a few different things…
    - Sold reduced monthly permits to companies that will manage their own tandem parking; we just 'enforce' to ensure that their employees are using the designated areas.
    - Assigned monthly users to tandem spaces (blocked by valet -/ transient parking) so they can keep their keys. Valet / transient vehicles park with attendant-assist
    - Once valets get used to the users' schedules, we often don't have to move a valet / transient vehicle at all
- Topic: Part-time Employees:
    - We have identified two user profiles that are most likely violate parking policy by either parking/re-parking in free areas or in residential areas
        - Those that work all day 1-3 days per week
        - Those that work less than a full day (1/2 day) 4-6 days per week

- We have considered, but have not had great success with, the concept of offering multi-monthly discounts
  - Restaurants are a good example of where this can work, but there is typically no one that is assigned the task or willing to organize their parking. The business usually takes an arms-length approach to their employee parking problem, leaving the parking authority to deal with the issues.
  - The concept of "multi-monthly discounts" is that the business may have 10 or 20 employees, but there may only be 5 employees present at any one time
    - Under this concept, the City would allow businesses to purchase 5 full price monthly parking permits and then as many additional permits at a reduced rate (1/2, 2/3, whatever) but only allow 5 vehicles in the facility at one time. Most modern parking access and revenue control systems (PARCS) can provide the capabilities to manage this approach.
    - The key issue is having a program that can be communicated to the business and getting the business to be an active partner

- Topic: Evening Employee Parking:
  - For evening employee parking, we identified an 'exit window' that most of the evening employees (mostly restaurants) were leaving the facility. We created a reduced flat rate based on time of exit of $2 or $3. This means that if you arrived to work at 5pm and exited the facility between, say 10p-12a, your fee would be a flat rate of $2. If you exited at 9pm, it would have been $6 or even $18 if you were paying the day/hourly rate and not the standard evening flat rate.
  - This program was created when we installed pay-on-foot equipment in our facilities and were collecting fees 24 hrs a day. The local restaurants were complaining that their business was down because people used to grab dinner after work (like 7/8pm) and wait until the attendant left for the evening at 9pm to exit free. We made a compromise to help address the issues of restaurant patrons with the reduced flat rate window, which also became a benefit for evening employees.
- Topic: Below-Market-Rate Parking for Employees:
  - We piloted a Below-Market-Rate program with the Chamber of Commerce as the administrator of the program.

    - We sold the Chamber a book of reduced rate monthly/daily passes at a 50% discount

    - The program stipulated an hourly wage cap to ensure it was going to those least likely to purchase (or afford) monthly parking and abusers of the park/repark or residential areas.

    - The Chamber added a small 'fee' for the sale of the permit to cover their costs.

  - If you can find a way to get the local business to be an active partner, I think that is one of the best ways to both find solutions and offer more organized programs. For instance, you offer the business the ability to purchase the parking at the extreme discount, there is connectivity to the business and accountability for usage/fraud.

    - With respect to wait lists, one of the things to consider/manage is who is on the list.

    - One of the things we found that told us we were too far below market, in that people that already had convenient parking were on our waiting lists for 1-2 years because it was so much cheaper.

    - Consider how many spaces you will allow a single user/business to place on the list and let people know up front how long from the time you notify them of available parking you will wait until you go to the next person on the list.

City of Lincoln, NE

Topic: High Parking Demand – Parking Supply Issues:

- The City of Lincoln has reached the point of demand that has us looking at constructing a new garage. In the meantime, however, the two programs we are looking at most closely are:

  - On-street permit (digital) parking in remote metered spaces.

  - Subsidizing bus ridership for current monthly parkers in an effort to "buy back" some of the monthly spaces currently in use.

- We are also looking at the shuttle option to better access the existing parking in some of our outlying areas but the cost is not in line with the current budget. Perhaps if the need becomes more critical this option will become more attractive.

City of Houston, TX

Topic: Managing the high costs of providing employee parking:

- We are at the point where we need to make some recommendations to the Mayor about the Employee Parking & Transit Program. We spend about $4 million/year on parking/transit for City employees. The City pays for either a parking space or a transit pass.

- Recently, all our paring rates just went up and we are looking at ways to better manage this program. We've done a quick survey of other employers in the area and it's an even split between those who pay for parking and those employers who partially pay for the parking.

- We are interested in "parking cash out" for the employees but it's a hard sell because taxes are impacted. But we are considering partial subsidies of parking and full subsidies for transit. Note: Parking cash out is a program that allows employees to opt out of having a parking space and instead receive compensation. The employer who leases (or owns) a space pays the employee not to park.

- We have a vanpool and carpool program and those vehicles have preferred parking, but the scale of this initiative is small and in the past, interest has been limited. For employees who opt for transit, we offer 12 days of free parking in the garage if they need to drive (per year) and we also offer emergency transportation for transit employees (we call a taxi – only have had to do that once since we've taken over the program).

- We also require all employees enrolled in the transit & parking program to resolve any outstanding parking citations to their personal vehicles in addition to billing departments when employees fail to resolve parking citations on city vehicles.

- Finally, we incorporated peace officer parking into the rollout – as you know, peace officers park anywhere and everywhere – we have a general order that prohibits them from parking within 4 blocks of headquarters if they work at headquarters, but this is routinely violated. Additionally, they would leave a badge or a ball cap or homemade placard on the vehicle which we were not in favor of.
    - Now we issue placards to the police department employees – if they work in headquarters, they get a blue placard – so they may park at a meter but it can't be within 4 blocks of headquarters. If the peace officer works at the one of the satellite offices, they get a yellow placard which allows them to park in the vicinity of headquarters.

- I feel like we just encourage single occupant vehicle (SOV) usage and contribute to the traffic madness instead of leading the way out of it. See Houston's Employee Parking Administrative Policy on the program and the memo they sent to the Mayor's office with their recommendations (see Appendix).

4 STRATEGIES FOR MAXIMIZING EXISTING PARKING RESOURCES

1. **Parking Program Marketing and Signage**

The development and implementation of a strong parking and access management brand, including the design of new parking facility signage and decals for on-street parking equipment can improve facility utilization. The development of new parking signage will be an important and highly visible element of the new branding program.

2. **Parking Resource Allocation Policies**

The shifting of current employee parking allocations to remote or peripheral garages should generate increased revenue because hourly rates are typically higher that monthly rates and there is the potential for increased turnover and therefore increased revenue per space.

3. **Event Coordination**

Under normal circumstances (non-peak demand periods) there are excess parking spaces in City garages. Utilizing these spaces for event parking needs during non-peak demand times (would not affect portal capacity issues) should be considered as a source of additional parking revenues. Working collaboratively with Mayo Clinic to utilize some of their parking resources that are within reasonable proximity to downtown events (during not-peak times) is also recommended (potentially utilizing a revenue sharing arrangement).

4. **Strategies to Better Utilize Public and Private Parking Resources**

In downtown Rochester, there are approximately 28,600 total parking spaces. Of this total, over 21,500 are privately owned and operated (including 14,228 Mayo owned or leased spaces). In many communities, the utilization of private spaces can be 50% or less, creating an opportunity to shift at least a portion of those spaces to public use. Finding opportunities to increase the number of private spaces that can be used for public parking can be an effective strategy to increase parking options for a wide range of parkers, especially in an environment where funding for new public garages is diminishing. Typically, the City parking management program can manage these "excess" spaces for the private entity for a management fee or a revenue sharing arrangement. The following strategies are recommended for consideration.

- Allow and encourage shared private parking between uses with parking demands peaking at different times of the day, week, or year.
- Shift to building more public and less private parking by allowing or requiring developers to pay into a fund to be used for building public parking rather than providing parking spaces on-site (In-lieu-fees).
- Allow property owners with excess on-site parking to lease extra spaces or charge the public to use them during the site's off-peak hours, or allow them to

redevelop the excess space as building space if they pay into a fund to be used for building public parking

- Sometimes private parking owners are reluctant to open their parking facilities to public use after hours, because of concerns related to vandalism. In these cases, providing some level of insurance or operating the spaces on a valet basis can overcome these concerns.
- Charge for on-street parking where demand exceeds supply. If there are already meters for on-street parking, raise hourly rates, or allow meter rates to vary with demand. To make this more palatable, make payment easy using advanced meter technology.
- Discourage shop owners and employees from parking in front of their stores or the stores of their neighbors. In high demand areas, this can often be accomplished by increasing enforcement routes.
- Consider allowing public parking in the public facilities that are typically dedicated to City uses during the day (for example spaces reserved for City Hall employees or courthouse jury parking) after hours and on weekends.

A new area of potential for maximizing the utilization of existing private parking assets involves on-line search engines that steer drivers towards the cheapest and most convenient parking facilities. Millions of customers access these websites across the country and many of the largest parking operators in the country partner with the "on-line parking brokers" to rent parking spaces on both a daily and monthly basis. Motorists can search for parking by neighborhood, address, cross-street or attraction. All parking garages and lots near the search destination appear on a map and sortable list. Details for each facility are posted, including addresses, phone numbers, capacity (if available), indoor/outdoor, clearance height, electric vehicle charging, etc.

There are now several of these types of services available for review and assessment including:

- Best Parking
- Park Whiz
- Parking Panda
- Spot Hero
- Click N Park (SP+)
- Parker (by Streetline)

Also – both ParkME (acquired by Inrix) and Parkopedia have partnered with some of the apps in different geographies to allow for booking within their sites.

5 WHY SHOULD EMPLOYERS AND MUNICIPALITIES CARE ABOUT PARKING?

The following section was modified and updated from an excellent document originally published by Metro in Seattle, entitled ***Managing Employee Parking in a Changing Market***. Metro developed this handbook for use by employers who provide parking for their employees. Production of this handbook was made possible by a grant from the Federal Transit Administration. Eileen Kadesh of Metro's Market Development section and Diana Ehrlich, a graduate student at the University of Washington, coordinated development of this guide.

At first glance, parking management – management of the location, cost, availability and demand for parking – may not seem like a very important topic. Yet, there are three good reasons why employers and municipalities should take a fresh look at their parking policies:

Reason No. 1: Effective parking management can save you money.

- Employers and communities who own their own sites will find effective parking management can help them recoup the cost of their initial investment in parking.
- Employers and communities who lease their sites and do not pay a separate charge for parking in their leases may gain more control over the number of parking spaces assigned to them by developers or building management. This change can lead to more competitive rents.
- Effective parking management can help employers and communities avoid the need to build new parking spaces or lease additional parking.
- Where employers reduce parking supply or charge market rates for parking, they also may reduce drastically the cost of setting up a trip reduction program.

Reason No. 2: Effective parking management is one of the best ways to influence employees to stop driving to work alone.

- Research has shown there is a strong relationship between the availability and cost of parking and the choice of a commute mode. More than 75 percent of the people who drive to work in U.S. cities use parking provided by their employers. And 90 percent of those workers don't pay to park. For many employers, free parking at work is a stronger incentive to drive than if their employer offered instead to give them free use of an automobile and free gasoline for their trips.

Reason No. 3: Parking is Expensive

- Employers spend a tremendous amount of money on parking. Costs associated with parking include taxes, construction and maintenance, in addition to the opportunity costs of converting spaces to uses with higher financial return.

- A 1985 survey in southern California found the cost to firms for employee parking ranged from $26,000 to $377,000 a year, with a median of about $40,000 a year.

- About 75 percent of suburban economic center parking is surface parking. A well-designed facility uses 300 to 325 square feet per car, including space for aisles, landscaping and other features. Surface parking costs approximately $11 to $16 per square foot to build, including paving and drainage, lighting, landscaping and basic access and revenue control equipment. A parking stall of 320 square feet, therefore, would cost between $3,500 and $5,000 per space in 2017 dollars.

- Parking structures cost $18,000 to $32,000 per space, depending on their height and design, plus the cost of land in 2017 dollars. Below-grade parking can cost 1.5 – 2.0 times the cost of above grade parking structures per space to develop. A parking fee of approximately $200 per month would be required only recover this capital cost. An additional charge would be necessary to cover operating costs.

Why do employers provide free parking?

- Employer-provided parking subsidies have been an integral part of the benefit package used to attract and keep employees. These subsidies can be direct (employers buy or reimburse employee parking) or indirect (employers pay higher lease rates). Indirect subsidies are most common in suburban areas.

    - Parking subsidies are nontaxable to $155 per month, so employers can provide a fringe benefit with a value that exceeds the same amount of taxable income.

    - Suburban employers do not normally have parking costs itemized separately in their building leases. The total rent includes the cost of parking for those employers. Thus, suburban employers usually do not know how much it costs them to provide parking for their employees. They also have no monetary incentive to encourage their employees to use less parking. Those conditions have led to abundant free parking in the suburbs.

- A survey conducted by the Orange County Transit Authority in California asked 50 employers who did not charge their employees for parking their reasons for that policy (employers could respond more than once). Ninety-two percent said they provided free parking because it's considered an employee benefit. Many employers (42 percent) said they never considered the issue. Twenty percent said charging for parking would be too time consuming. Only one employer suggested a union or employee contract as the reason. These findings confirm the prevalent view of parking by employers – free parking is standard practice and largely a non-issue.

6 IT'S TIME FOR A NEW PERSPECTIVE

We want to make the case for reconsidering your business' or community's employee parking policies. Below are some compelling reasons such a strategy will become critical in the next few years as companies (and cities) struggle to remain competitive.

Market Conditions are Changing

Several factors will affect employer parking policies during the next decade:

The Commute Trip Reduction Law

- Many communities are affected by state Commute Trip Reduction (CTR) laws. Undoubtedly, some employers will consider parking strategies only as a last resort. But others are looking ahead and realizing that commute alternative programs often have poor results when parking is plentiful and provided free to employees.

- If employers reduce parking supply or charge market rates for parking, the cost for setting up a CTR program can drop drastically.

Tightening of Parking Supply

- Of the 52 employer demand management programs featured as models in the CTR guidelines, 50 percent began because of parking shortages at the work site. Many companies facing a shortage of parking, decided to meet the goals of the CTR Law by not building or leasing any new parking.

- Hospitals are one type of business facing a changing market for parking. As the number of outpatient surgeries increase in comparison with lengthy hospital stays, the need for more outpatient parking is becoming apparent. Hospitals offered significant incentives to their employees mainly to ease the parking situation and provide more spaces for patients.

Increasing Flexibility in Leases

- Some building management companies will let tenants out of their leases under certain conditions. The tenants can turn in parking spaces they no longer need and reduce their costs proportionately. Until now, tenants in those buildings did not know their parking cost because the lease did not itemize it separately. Market conditions in in many downtowns make it more advantageous for lessors to rent parking spaces daily, instead of monthly. So, if an employer in this situation can persuade some portion of its employees to give up their cars and shift to alternate modes, the company can save money.
- Boulder Colorado employees the acronym S.U.M.P. to describe their overall approach to parking. S.U.M.P. stands for: Shared, Unbundled, Managed and Priced

Economic Conditions

- Because of the state of the economy, many companies are finding they need to cut costs to survive. Companies can save money by changing their parking policies in several ways:
    - Charge employees for parking or simply stop providing parking, requiring employees to find their own parking or choose other ways to commute.
    - Decide not to build or lease additional employee parking and focus instead on reducing the demand for the limited parking supply.
    - Convert excess parking supply to uses that are more profitable or beneficial to employees. Some ideas are to lease the parking to other companies, construct additional buildings on the space or convert the parking area to open space with a recreation or picnic area for employees.

Desire for More Choice

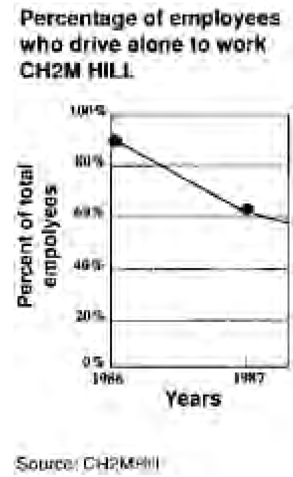
- Employees are beginning to ask for an array of transportation choices as part of a benefit package. In response to this request and the need to reduce solo driving, some employers have begun to broaden their definition of accessibility from simply providing parking to offering a range of commuter services. Free parking by itself may not be enough to satisfy employee expectations.

- What would commuters do if employers did not subsidize parking? Researchers in Seattle who have analyzed case studies in the United States and Canada suggest that at least 20 percent of commuters who now drive alone would choose to carpool or use public transit if employers required them to pay market rates for parking they now receive free.

- Local studies provide comparable numbers. In a survey by Metro in downtown Seattle, more than 30 percent of the employees interviewed said they would drive alone less or ride the bus if they had to pay the full price of parking. Of about 24 percent of employees interviewed in downtown said they would try ridesharing or use transit if parking costs increased significantly.

- Some employers might dismiss survey results by concluding that what people say they will do is far different from what they really do. Following that concern, below are the experiences of two employers who stopped subsidizing employee parking.

Case Study # 1: CH2M Hill



- CH2M Hill, a transportation engineering firm, faced a major challenge when it moved from a suburban area to downtown Bellevue, WA. Of the 89 percent of employees who drove to work alone, 80 percent said no alternatives would make them switch. Despite that response, a parking charge of $40 per month (scheduled to increase each year until it reaches market rate), a new comprehensive parking management program and commute subsidy program produced dramatic results. In one year, CH2M Hill's single-occupant vehicle (SOV) rate dropped from 89 percent to about 62 percent - a 27 percent reduction in SOV commuting. Today, the company still maintains a 50-60 percent SOV rate, in an area where the average SOV rate is 82 percent.

Case Study # 2: Bellevue City Hall

- Bellevue City Hall traditionally had more employees than parking stalls. It responded to the parking shortage by charging a parking fee of $30 per month. The SOV rate for the site dropped from 75 percent to 55 percent the following year - a 20 percent reduction. Key to that success was the fact that the parking charge was only one part of the city's rideshare parking management program. Besides the parking charge, the program featured a transportation allowance to all alternative-mode users, a bus-pass subsidy, a fleet-ride program and a guaranteed ride home program. Of note is Bellevue City Hall's location outside the downtown area because transit service is not readily available.

7 EXPLORING THE EMERGING FIELD OF SHARED MOBILITY

The emerging area being referred to as "shared mobility" provides great promise for offering a range of alternatives that can help mitigate the need for employee parking by providing a menu of alternatives to single occupant vehicle usage. An "eco-system map" was recently created for the Silicon Valley "Mobility as a Service" project, where mobility aggregators are beginning to integrate various programs and services.

The menu of shared mobility options provided below identifies several major categories related mobility as a service. Examples for each category are provided below. For more information on specific programs a Google search by the program name will generally provide a good overview of program scope and options.

- Enterprise Commute Trip Reduction (Examples: Luum, Ride Amigos, etc.)
- Mobility Aggregators (Examples: Moovit, Moovel, Urban Engines, etc.)
- Public Transit

- Private Sector Transit (Examples: Bridj. Chariot, Go Carma, Via, etc.)
- Rideshare w/in 10 min (Examples: Lyft Carpool, UberPool, Ford Dynamic Social Shuttle, etc.)
- Rideshare w/in 24 hours (Examples: Carma, HOVee Carzac, etc.)
- Taxi-like services (Examples: Lyft, Uber, Juno, Sidecar, etc.)
- Carshare (Examples: Car2Go, Zipcar, Enterprise Car Share, etc.)
- P2P Carshare (Examples: Getaround, RelayRides, Ford Car Swap, etc.)
- Bikeshare (Examples: Motivate, DecoBike, Bcycle, NextBike, etc.)
- Personal Electric Transport (Examples: Enzo foldable ebike, GenZe electric bikes, Scoot (heavy scooter rental, etc.)
- Vanpooling (Examples: Enterprise, Vride, etc.)
- Commute Mode Detection Technologies (Examples: Strava, MapMyRide, Moves, etc.)
- Smartphone Transit Payment (Examples: Passport, GlobeSherpa, Masabi, etc.)
- Smartphone Parking (Examples: ParkMe, Parkmobile, Pay-by-Phone, etc.)
- Miscellaneous Apps (Examples: City Mapper, Transitscreen, Modeify – TDM Trip Planner, etc.)
- Commuter Benefits (Examples: Commuter Check Direct, Commuter Benefits, Wageworks, etc.)
- Robotaxi (Uber w Robot Driver)
- Personal Rapid Transit (Examples: 2getthere, Ultra Global (London Heathrow), etc.)
- Niche ride match (Examples: Zimride, Otto (eRide Share), etc.)
- SOV Apps (Examples: WAZE social traffic, Twist for Rendezvous, etc.)
- Niche Transport (Examples: Boost by Benz, Shuddle, Hop/Skip/Drive, etc.)

As parking and TDM programs merge to offer more comprehensive tapestries of “access and mobility management strategies”, this document canbe a helpful and informative resource that illustrates the scope, variety and evolution of this emerging area of the parking industry that is now being calling "shared mobility".

8 MAKING A CHANGE

The following is one recommended approach to evaluating an overall approach to employee parking programs. These strategies may be useful for the new TMA or TDM program to promote to local employers.

Employee Parking Program Assessment Strategy

After calculating your company's cost for providing employee parking, you may decide you are ready for a change. If so, here are a number of steps to be considered in developing parking management strategies:

1. Solicit top management support for parking management.

2. Form an internal committee to evaluate the parking situation and help propose strategies and solutions.

3. Evaluate site characteristics. Inventory existing parking supply and use.

4. Define objectives for parking management, and evaluate appropriate actions.

5. Check labor union agreements for parking stipulations (if applicable). Include a labor representative on your internal committee.

6. Review the costs or savings associated with each strategy. For carpool and vanpool parking subsidies and preferential spaces, assess future costs by first estimating demand.

7. Integrate parking management strategies into the total commute trip reduction program.

8. Market the parking management program with the marketing of other transportation alternatives.

Above all, don't carry out parking management in isolation, but include it as part of a total commute trip reduction program. Couple parking restrictions with other transportation alternatives - all as part of a total transportation benefit package. Without sufficient alternatives, unhappy employees who continue to drive to work alone may be the most noticeable result!

ADDRESSING EMPLOYER CONCERNS

Employers cite a variety of arguments to justify continuing employee parking subsidies. Many of these concerns, however, are based on inadequate information or failure to fully explore the wide range of solutions available. Here are the most common reasons for not tackling the issue of parking subsidies:

If employers charge for parking, employees will quit

Many local companies can testify that dropping subsidized parking by itself does not cause employees to quit. The key to a successful program is offering positive choices to employees. Employers should not begin a parking charge without offering attractive alternatives to driving alone.

Charging for parking is an administrative burden

Setting up a computerized payroll deduction system is one way to administer a parking charge efficiently. Time spent administering the program is limited to start-up and occasional changes. Some companies, however, believe employees are more aware of the amount they pay for parking if required to write a separate monthly check, instead of having the fee taken out of their paychecks automatically. For any system, revenue from the parking charge should exceed the cost of administering the program.

Union concerns

Most employers have not raised the issue of parking with their unions. This is still a largely unexplored area. However, employers will need to check with unions if they propose to take away free parking and should plan to offer other transportation benefits to balance the perceived loss.

Inadequate commuting options for employees

Companies have taken widely varying approaches to overcome the problem of inadequate transit service. Some have paid for special shuttles that run between nearby park-and-ride lots and their work site. Others have begun their own vanpool program. Others have worked with local transit agencies to begin special shared-cost transit service plus vanpools tailored to the needs of a specific employee market.

When highly promoted by company management, ridesharing also can be effective for companies in low-density areas. Kenmore Trucks in Seattle achieved a 66 percent SOV rate primarily by promoting the use of carpools and vanpools with a combination of reserved parking spaces for rideshare vehicles and general tightening of parking supply has been an effective incentive for employees to leave their own cars at home.

Inability to change an employer's parking allocation written into its lease agreement

An increasing number of building management companies are willing to allow some flexibility in lease agreements. That flexibility is still the exception, however. Employers must check with their building management to discuss the potential for reducing their parking allocation and associated costs.

Potential for employees to park free on streets or lots next to the work site

This problem is very real and is one major reason to support on-street paid parking. Paid on-street parking reserves these most convenient parking spaces for customers (and not employees). Providing cost-effective employee parking areas, ideally at a range of cost points can free off-site parking and support a range of other commute options for those employees willing to consider these alternatives. Stricter and more effective parking enforcement measures, such as leveraging new mobile license plate recognition technologies and towing from lots of adjacent businesses, also could help with reducing "spillover" parking.

The need to deal with multiple sites

An employer with multiple sites may find there are equity issues in beginning a parking management program at one site and not providing the same program at the company's other sites. Readily available transit service may help justify dropping a parking subsidy at a downtown site. Labor unions may complain, however, about a parking policy that does not apply company wide. One solution may be to offer other incentives to accompany a parking charge.

9 PARKING MANAGEMENT STRATEGIES THAT WORK

It is not expected or even recommended that employers make a sudden change from completely subsidizing employee parking to charging employees the market rate.

Instead, a thoughtfully considered plan undertaken incrementally may be the most successful approach. Following are some ways to get employees on your side by introducing a parking charge gradually:

Introduce a parking charge for new employees only.

Many companies successfully using this approach to ease into priced parking. The impact of such a strategy will depend on the company's rate of attrition and turnover. Gradually over the years, the parking charge will come to apply to most of the site's employees.

Allow employees to 'turn in' their parking spaces voluntarily in exchange for receiving the cash value of the parking space ("Parking Cash Out").

The theory behind this strategy is that asking commuters to choose between a free parking space and its cash value makes clear that parking has a cost - the cash not taken. The new "price" for taking the 'free" parking would increase the perceived cost of solo driving to work.

Compared with other solutions to the employer-paid parking problem, the cash option requirement is least intrusive in the employer's decisions about employee compensation. The only added cost for an employer would be requests from current "ridesharers" for the cash value of parking subsidies they have not taken.

In choosing between a parking subsidy and its cash equivalent, employees would have to know the cash is taxable, while the parking subsidy is not. Research on commuters in Los Angeles, however, suggests that the taxable nature of cash does not diminish its attractiveness seriously.

For more information on Parking Cash-Out – See the link at the end of this paper. Parking Cash Out was published by the American Planning Association and written by professor Donald Shoup. Note: IPI just sponsored a webinar on this topic based on some recent research into the effectiveness of parking cash-out programs. This information can be provided upon request.

The following six strategies were assessed as part of this research:

Scenario 1:	Monthly Parking Cash-Out
Scenario 2:	Monthly Employer-paid Transit/Vanpool Benefits
Scenario 3:	Monthly Parking Cash-Out + Incentive for Daily Cash-Out
Scenario 4:	Monthly Parking Cash-Out + Pre-Tax Transit Option for Employees without Subsidized Parking
Scenario 5:	Incentive to Eliminate Employer Subsidized Parking + Provide Employer-paid Transit/Vanpool Benefit
Scenario 6:	Peak Parking Surtax

Provide a transportation allowance.

Some companies, offer a transportation allowance when they introduce a parking charge. A transportation allowance is usually a salary increase provided to all employees or to employees who do not drive alone. If a company levies a $40 parking charge, for example, the company may provide all employees a $40 transportation allowance. To be effective, the parking charge should be high enough so that the out-of-pocket cash required to make up the difference between the transportation allowance and the parking fee serves as a disincentive to park. Employees who do not drive alone can pocket the extra cash. Some companies provide a transit, carpool or vanpool subsidy besides the transportation allowance.

Begin a parking charge for single-occupant vehicles, but provide discounted or free parking to "ridesharers".

When carpoolers split the cost of a normal parking charge, they already cut their parking costs. Reducing the parking charge for rideshare vehicles even more provides a significant incentive for employees to carpool or vanpool. Some businesses allow carpoolers to park free, sending a powerful message to employees that company management values and supports ridesharing. While the employer does not gain revenue from parking spaces provided free to "ridesharers", it reduces the need for more parking. The company then may be able to reach its commute trip reduction goals or reduce their parking problems as more employees use carpools for commuting.

Begin with a low parking fee and increase it annually until it reaches market rate.

Although this plan can help generate some revenue for the employer, it will not cause a significant shift to alternative commute modes for several years. As such, it is probably not as effective as beginning with a moderate charge and increasing it to market rate faster. This incremental increase will give employees a chance to adjust to the idea of paying for parking.

Provide employees with other transportation incentives while introducing a parking fee.

Incentives such as a "flexpass" program, free parking days for ridesharers and guaranteed ride home are examples of programs that can help employees accept a parking charge.

10 SYSTEMS AND EQUIPMENT TO SUPPORT EMPLOYEE PROGRAM IMPLEMENTATION

In addition, we have also provided several equipment/programmatic approaches that readers may find interesting. The resource section of this white paper includes:

- Parking Logix - The OpenSpace™ Counting Solutions are sensor-enabled speed humps for parking facilities. It includes an embedded sensor which detects and counts vehicles as they drive over the humps while entering and leaving a parking facility. The sensors can differentiate between motorized (cars, trucks, etc.) and nonmotorized (bikes) traffic to provide accurate vehicle counts for oncoming motorists. OpenSpace™ sensors have been designed with a battery life of 3 years and are covered by a full 2 year warranty.

- Parkifi - Parkifi provides real-time spot occupancy visibility on an easy-to-use dashboard, potentially making a city's on- and off street spots more profitable and efficient.

- Streetline - Parking Data and Analytics: What Can Your Parking Spaces Tell You?

- Locomobi - is an information technology leader that delivers innovative enterprise hardware and software solutions, including a revolutionary License Plate Recognition (LPR) system, for some of the biggest names in parking and transportation in North America. LocoMobi's full vertical integration allows for the unique ability to custom tailor true end-to-end parking and transportation systems through modular application. From equipment and hardware to cloud-based solutions and mobile payments, LocoMobi accommodates a broad range of environments that include municipalities, commercial and residential buildings, airports, universities, hotels, self-storage facilities and campgrounds. In addition, LocoMobi provides unique solutions for the tolling and transit markets.

- LUUM – See link to Seattle Children's Hospital Case Study in the Appendices

11 IN SUMMARY…

Changing your parking policy to help maximize the use of existing parking resources doesn't have to be painful. Parking management can help your company save money and, simultaneously, free up parking for customers and other visitors. You can use it to reward employees who rideshare and increase employee satisfaction by making company transportation programs more equitable.

To begin reshaping your parking program, the following steps are recommended:

1. Calculate your parking costs. Use the sample parking cost worksheet in the appendix of this handbook.

2. Forecast your parking needs. With an aggressive CTR program, can you reduce your supply?

3. Check your building's lease for parking provisions. Perhaps you can negotiate a reduction in your parking allocation with the building management.

4. Form an employee parking committee to help design your parking benefits package. When you involve employees from the beginning, they will be more willing to accept the program you eventually adopt.

12 APPENDICES/RESOURCES

Employee parking program vary greatly depending on a wide range of factors including community size, program sophistication, parking supply/demand, availability of high quality transit and transportation alternative programs.

In the Appendices/Resources section of this paper, we have included a variety of "case study examples" which we hope will provide both examples of the variation in program types and specific program elements. These "case study examples" come in the form of program policies, marketing and employee information documents.

Probably the most advanced and sophisticated program we are aware of is the excellent program developed and implemented at Seattle Children's Hospital which has evolved into the LUUM software program. A case study of this program can be found at: http://www.nunes-ueno.com/case-study.html.

Another great resource noted in this paper is a document created by the Association of Commuter Transportation entitled: ***Getting to Work – Spotlight on Employer-Sponsored Commuter Programs***. This document can be found at: http://actweb.org/wp-content/uploads/2017/01/Getting-to-Work-Jan-2017-Final.pdf

The Donald Shoup book on ***"Parking Cash-Out"*** is another recommended resource. This book can be found at: http://shoup.bol.ucla.edu/Parking%20Cash%20Out%20Report.pdf

In addition to the resources noted above, the following additional resources are provided as separate documents:

- Appendix # 1: ACDA Employee Parking Program
- Appendix # 2: UNC Employee Parking
- Appendix # 3: Sacramento Discount Employee Parking Program
- Appendix # 4: City of Palo Alto, CA - A Better Place to Work & Park
- Appendix # 5: Newport Beach, CA – Employee Parking Program
- Appendix # 7: MUSC Employee Parking Services
- Appendix # 8: Generic Employee Parking Policy
- Appendix # 9: City of Pomona – Employee Parking Policy
- Appendix # 10: Phoenix Sky Harbor Airport Employee Parking Policy
- Appendix # 11: City of Houston Employee Parking Policy
- Appendix # 12: Mayo Clinic Employee Parking Brochure
- Appendix # 13: Mayo Clinic Nursing Parking

Appendix 8

Assessing an Uncertain Transportation Future

Projecting the Impact of Autonomous Vehicles and Shared Mobility Trends on Future Parking Demand

Research Memo

Prepared for:

DMC Transportation & Infrastructure Program
City of Rochester, MN

Prepared by:

Kimley»Horn

July 10, 2017

DMC Rochester J8618-J8622 Parking/TMA Study

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EXECUTIVE SUMMARY

Assessing an Uncertain Transportation Future

Overview

The supply/demand projections being developed as part of the DMC Parking and Transportation Study are based on current parking planning paradigms, assumptions and methodologies, but this report delves into a national discussion that is taking place related to the several important questions related to emerging technologies and social trends that could dramatically impact traditional parking planning and the quantity of parking that is provided over the course of the next several decades.

As the base "Park +" parking demand model is being finalized, this document is being issued to provide some background on emerging issues that will likely have an impact on parking supply/demand in the future. While there is still much uncertainly on the impacts and timing of these changes, this document represents the most current research and opinions on the evolving and dynamic transformations occurring in the transportation industry.

Task Report Summary

Assessing an Uncertain Transportation Future explores several key areas that experts warn are likely to produce "significant disruptions" to the parking and transportation industries in the coming years. Specifically, the strong emergence of autonomous vehicles (AVs) as a potentially viable reality brings with it many positive elements, including greatly enhanced vehicular safety, a dramatic reduction in automobile related deaths and injuries, reductions in roadway congestion, reductions in vehicle emissions (assuming future AVs will primarily be electric vehicles), and especially significant to this study, the potential for a dramatic reduction in parking demand. Some estimations project that once autonomous vehicles are the dominant form of personal transport, parking demands could drop by as much as 40% – 50%. There are other shifts taking place in the transportation sector such as the emergence of what is being called "shared-use mobility" which ties to the changing preferences of younger generations to purchase "mobility as a service" instead of owning a vehicle.

A key element of these issues relates to the timing of these changes and how these changes are likely to unfold. The pace of advancement in vehicle technology, lidar and vehicle sensors, and connected vehicle technology such as GPS and in-car navigation, has been dizzying. This rapid advance, and the corresponding decrease in the costs of these technologies, has created a great deal of media attention leading to a wide range of opinions and speculation about the timing and impacts of the application of these transformative technologies. To be clear, there are many conflicting opinions about the true impacts these industry changes will bring. Some argue that vehicle miles traveled (VMT) will decrease, while others argue that VMT will actually increase. Some argue that single occupant vehicle use will decrease substantially, while others warn of an emerging and even less desirable phenomenon—zero-occupant vehicles (AVs with no passengers driving from place to place to pick up customers). Some argue that vehicle ownership rates will plummet, while others suggest that while vehicle ownership may decrease, the total number of vehicles on the road will actually increase.

Beyond these uncertainties, a host of other potential issues have also yet to be addressed—legal issues, regulatory issues, insurance issues, cost issues, significant job losses in a number auto and driver-related industries and more. These could all impact the predictions of when changes will begin to impact parking demand. Another factor to consider is geography. Most experts agree that many of these pending changes will happen first in major urban areas, with adoption lagging behind in more rural areas.

This report attempts to summarize the current state of the technological and policy issues, as well as provide the projections of leading industry experts related to implementation timelines of these emerging technologies. Based on this research, we will provide a set of recommendations related to parking and access planning, specifically related to new parking development. The primary concern we are trying to address is what is right amount of parking that should be provided, both in the short to medium term (3-10 years) and in the longer term (10-40 years).

Recommended Strategies

In general terms, we are recommending a combination of strategies that attempts to bridge the gap between providing adequate parking, based on the current transportation and parking paradigms, with projections for reduced parking demand in the longer term. We are also recommending a specific approach that attempts to merge a focus on effective parking management with a more comprehensive “access or mobility management” approach to community access overall. This approach promotes an integration of parking and transportation strategies as a means to minimize parking infrastructure investment without compromising service levels for the community overall and a strategy to provide the bulk of commuter parking outside the defined “portal capacity” boundaries to minimize future traffic impacts.

With a more aggressive posture related to an integrated parking/mobility management approach, which will provide less total parking an increase in mobility options will be needed in the short to mid-term timeframes, which is important because of the uncertainty of how much parking will be needed in the future. We believe that this approach can also provide significantly higher levels of customer and staff service and satisfaction levels. To support this recommendation, two previously provided appendix items are referenced and include: an essay defining the “**20 Characteristics of Effective Parking Programs** and an extensive **Parking Management Best Practices** document. These documents are intended as a road map to creating an enhanced parking management function and have been provided both to the City and to Mayo Clinic.

A key area of focus is the adoption and integration of a range of mobility management and transportation demand management strategies which will be implemented as part of a new Transportation Management Authority. These initiatives, if well-implemented, could reduce overall parking demand significantly and reduce the amount of parking needed in the short to mid-term timeframe. Another important component to this recommendation is a monitoring and evaluation component. If this recommendation is pursued, the goal would be to establish an initial baseline of parking and modal split metrics for the downtown area and update these metrics on an on-going basis. As the transportation system evolves over the next several years and decades, this monitoring system will provide data-driven management tools to assess changes in transportation options and parking demand, and determine which transportation alternatives have proven most effective.

If the demand for parking in the future is reduced by the projected 40-50%, progressive planners and architects are proposing options that would allow for parking structures that could be “adaptively reused” for other functions. This emerging concept has garnered much attention in recent months. This document also incorporates previously submitted materials for the types of changes that would need to be considered to create adaptable, “future-proofed” parking facilities.

As the base Park+ parking demand model is being finalized, this report is being provided to begin the discussion of how these potential changes to both the parking and transportation industries should be incorporated into future parking demand projections.

This report suggests that a phased parking development plan be considered (Phase 1 being the next ten-year period). The Phase one period could use traditional parking structure planning assumptions and development practices. However, any additional parking infrastructure development that may be needed beyond the next 10 to 15 years should seriously consider the adaptive reuse approaches outlined in this report. The initial phase parking facilities could also be developed using the adaptive reuse approach, but any adaptive reuse strategy will come with an initial cost premium in the 18-25% range. (This premium would cover the costs of such elements as increased floor-to floor heights, extra structural capacity, and external ramping). If these facilities were eventually adapted to other uses, such as office space, the value of this adapted space would off-set some, if not all, of the premiums associated with the design modifications. On the other hand, it is less likely that the initial garages would be candidates for adaptive reuse compared to the garages built at a later date. One caveat to this general line of thinking is that garages located more closely to certain buildings or functions might be better candidates for adaptive reuse based on their proximity to key development sites and types of development. We encourage the design team to consider the potential for garage adaptive reuse before making final garage site selections. This phased approach to parking garage development takes into account the uncertainty of the future as it may or may not affect future parking demand.

It is worth noting that this approach has already been implemented on the new Apple campus in Cupertino, CA. City code required approximately 14,000 parking spaces for the new campus. Apple built the parking, but strongly believed that future demand would be much less than the required spaces, and designed the two large rectangular parking structures to be reused for additional office space. To our knowledge, this is the first significant application of this concept for new garage construction in the country.

Overall, we are proposing a comprehensive and multi-dimensional approach to manage not only parking, but also a more robust integrated mobility management system. This approach will reduce parking demand in the initial term, reduce the potential for overbuilding parking, provide a higher level of campus access and customer service, and offer flexible strategies for meeting the parking needs of the future (whatever they may be).

Parking Structure Development Costs Update

Based on a review of several industry sources, including hundreds of completed parking structure projects of varying size, scope, and geographic location (omitting parking structures that are entirely below-grade because the cost of such structures is much higher), the national median construction cost for a new parking structure in 2017 is approximately **$19,000 – $20,000 per space or $56.99 – $59.00 per square foot**, increasing approximately 2.5% from 2015, when the median cost was approximately $18,600 per space based on historical data.

When evaluating the Minneapolis market area, the median construction cost for a new parking structure in 2017 is approximately 8.0%higher than the national average with a construction cost of **$20,769 per space or $62.18 per square foot**.

Construction cost data does not include items such as land acquisition, architectural and engineering fees, environmental evaluations, materials testing, special inspections, geotechnical borings and recommendations, financing, owner administrative and legal, or other project soft costs. Soft costs are typically 15% to 20% of construction costs.

FEATURES TYPICALLY INCLUDED IN A MEDIAN COST PARKING STRUCTURE:

- Precast concrete superstructure
- Attractive precast concrete facade, but with basic reveal pattern
- Shallow spread footing foundations
- All above-grade construction
- 8' 6" to 8' 9" wide parking spaces
- Glass-backed elevators and unenclosed stairs clad with glass curtain wall to the exterior
- Basic wayfinding and signage
- Open parking structure with natural ventilation, without mechanical ventilation or fire sprinklers
- Little or no grade-level commercial space
- Basic parking access and revenue control system
- Energy efficient fluorescent lighting

ENHANCED DESIGN FEATURES THAT COULD INCREASE CONSTRUCTION COSTS ABOVE THE MEDIAN RANGE:

- Cast-in-place, post-tensioned concrete superstructure for lower maintenance
- Attractive facade with precast, brick, metal panels, and other materials
- 8' 9" to 9' 0" wide parking spaces for user comfort
- Green Garage Certification following the Green Parking Council standards
- Energy-efficient LED lighting with occupancy and photocell computer controls
- Custom wayfinding and signage system
- Storm water management including on-site retention/detention
- Deep foundations, such as caissons or pilings
- Below-grade construction
- Enclosed stair towers due to local code requirements

- Enclosed parking structure without natural ventilation, where mechanical ventilation and fire sprinklers are required • Grade-level commercial space
- Mixed-use development where the parking is integrated with office, retail, residential, or other uses
- State-of-the-art parking access and revenue control system
- License plate recognition systems
- Parking guidance systems
- Count system with variable message LED signs
- Pay-on-foot parking revenue control stations
- Wi-Fi and cellular services

FACTORS AFFECTING PARKING STRUCTURE COSTS

People often think of parking structure development costs primarily in terms of dollars per space, however, there are many other factors that should be considered. The cost of a parking space is a product of parking efficiency (SF per space) and structure efficiency (dollars per square foot). Each component plays a critical role in determining the ultimate cost of a parking facility. Parking efficiency is the total gross area of a parking structure, inclusive of stairs, elevators, and all parking floors, divided by the number of spaces. Typical parking efficiency for an above ground, stand-alone garage is 300 to 350 SF per space. Many below-grade or mixed-use garages can have parking efficiencies of 400 to 500 SF per space. Factors affecting parking structure development costs include:

- **Geography.** Construction costs vary by location due to regional factors such as the cost of labor and availability of materials. In addition, factors such as higher seismic regions and soil conditions have a large impact on cost.
- **Number of Parking Levels.** In general, a larger-footprint parking structure with fewer levels will cost less per parking space than a taller structure with a smaller footprint. The cost per square foot of the first level at-grade is less than levels elevated above the ground. A lower-height, larger-footprint structure will have a higher proportion of the cost in the first level. Taller structures are heavier which affects the foundation cost. A taller structure generally has a less efficient parking layout, which translates into more square footage for each parking space.
- **Parking Below-grade.** Parking below-grade is much more expensive than parking above-grade. A five-level, above grade parking structure may cost $50 per square foot. If this same structure is depressed one level below-grade, the cost can increase approximately 15% to $57.50 per square foot. If the same structure is put two levels below ground, the cost increases even more because of the impacts of having to dig deeper (45% higher than the original cost or approximately $72 per square foot).
- **Structural System.** 60% to 70% of parking costs are in the structural system. As such, the type of framing system will have a significant effect on the cost of each parking space. There are two general types of framing layouts—short-span and long-span. Short span requires a column approximately every three parking spaces (27x30 feet square) to support the floor slab. Long span requires columns spaced 60 feet apart, with beams spanning over the stalls and drive aisle. Generally, short-span systems cost less per square foot, but negatively effects efficiency. Long-span systems cost more per square foot, but result in more stalls in the same square footage.

  The structural system can be cast-in-place concrete, precast concrete, or structural steel. The most cost-effective option depends on the project's location and the region's preferred construction methods. The selection of a system not common in the area will generally cause the cost to increase.
- **Foundation.** Structures built in areas with poor soil conditions requiring more expensive, deeper foundation systems will cost more. The difference between a shallow and deep foundation system can increase the price approximately 10% overall—taking the cost from $50 to $55 per square foot, for example.
- **Architectural Facade Treatment.** The appearance of a parking structure is important to the surrounding environment. The cost of making that structure more aesthetically-pleasing can affect the cost per parking space of up to 15%. If the structural system is used to create the architectural facade, the cost per square foot will be less. However, the use of

architectural elements in addition to the structural system will increase the cost. If the architectural design creates an inefficient structural system, the cost could increase drastically.

- **Total Parking Spaces.** A smaller project will cost more per space than a larger project. A 200-space parking structure on a small site may cost about 30% more per square foot than a 1,000-stall structure on a reasonably sized lot.
- **Parking Efficiency.** The cost of a parking space is the cost per square foot multiplied by the square foot per space. The more square footage per stall, the higher the cost.

Example:

– Typical efficiencies for short-span structures: 330-390 sf/stall
– Typical efficiencies for long-span structures: 300-340 sf/stall
– Typical efficiencies for mixed-use structures: 400+ sf/stall

Example:

Assume a 500-space structure costs $50 per square foot:

330 sf/stall * 500 stalls = 165,000 sf * $50/sf = $8,250,000

360 sf/stall * 500 stalls = 180,000 sf * $50/sf = $9,000,000

The difference is $750,000, or $1,500 per stall.

- **Premium Elements.** Program elements added to parking will increase the cost per stall. A photovoltaic system covering 50% of the top level can add approximately 25-30% to the building's cost per square foot of the building. However, there may be operational cost savings that can support this type of elements. A mixed-use component will also increase the cost per stall due to negative impacts on efficiency and the structural framing system. Special site conditions such as the need to reroute utility lines or perform substantial demolition may increase cost as well.
- **Market Conditions.** The cost of parking can be negatively and positively affected by market conditions by 10% or more. A normal bid market will generate four to six bids from qualified contractors. An aggressive bid market might see 10 or more bids, causing the price to decrease. This can also create concern if the bidders are not qualified. An impacted bid market might see one to three bidders and a price increase due to lack of competition.

In the end, most owners budget for parking in terms of dollars per space. To be as accurate as possible, it is best to understand the project in terms of parking efficiency as well as structural efficiency. Design decisions that enhance efficiency can often help make a project financially feasible.

Sources:

1. Fixr, Build a Parking Garage Cost (https://www.fixr.com/costs/build-parking-garage)
   Note: FIXR estimates a $59 per square foot cost, though their estimate of the national average stands between $50 to $70 for most projects.
2. International Parking Institute, "How Much Does a Structure Cost?" H. Dean Penny, Kimley-Horn
3. Victoria Transport Policy Institute, "Parking Costs" (www.VTPI.org)
4. Carl Walker, Inc., "Parking Structure Cost Outlook" (www.carlwalker.com)
5. *Parking Today*, "The Top 10 Issues Affecting the Cost of Building a Parking Space" by Watry Design

ASSESSING AN UNCERTAIN TRANSPORTATION FUTURE

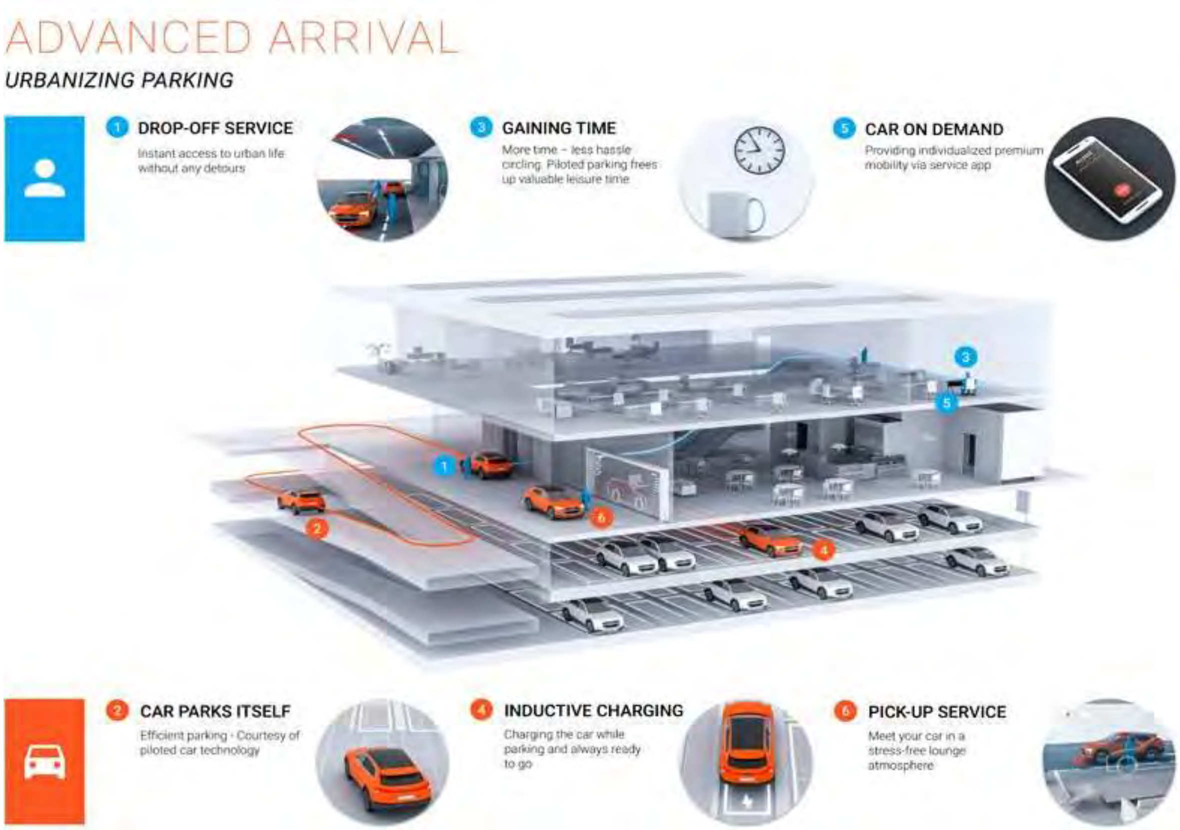
Assessing the Potential Impacts of Autonomous Vehicles and Shared-Use Mobility on Urban Transport and Parking

Overview

This section includes reviews and commentaries on autonomous vehicles and shared-use mobility, including an article written by noted transportation planner Todd Litman of the Victoria Transport Policy Institute. This article explores the impacts that autonomous (also called self-driving, driverless, or robotic) vehicles are likely to have on travel demands and transportation planning. As this is an emerging topic, general background information has been included in addition to specific issues related to the new campus.

This chapter begins with general commentary from industry experts regarding the nature and scale of the coming transformation of urban mobility, and the wide range of issues, potential disruptions, and impacts predicted. Our primary objective is to frame the national dialogue regarding these issues and create common context for the overall discussion. This overview is followed by a more detailed discussion of benefits and costs associated with autonomous vehicle (AVs), predictions related to development and implementation timelines, and explores how they will affect planning decisions such as optimal road, parking, and public transit supply.

While there are a wide range of predictions related to the timing of AV impacts (ranging from as little as five to ten years in more urban environments), Todd Litman's analysis indicates that some benefits, such as independent mobility for affluent non-drivers, may begin in the 2020s or 2030s. Most impacts, including reduced traffic and parking congestion (and road and parking facility supply requirements), independent mobility for low-income people (and the reduced need to subsidize transit), increased safety, energy conservation and pollution reductions, will only be significant when autonomous vehicles become common and affordable, probably in the 2040s to 2060s. Some benefits may require prohibiting human-driven vehicles on certain roadways, which could take longer.



Graphic courtesy of www.designboom.com

The Emerging Transformation of Urban Mobility

The following are excerpts from articles written by noted planners and industry experts related to the coming transformation of our transportation systems:

Getting Connected: What changes in technology mean for parking and municipalities in the 21st century and beyond.

Mark Braibanti | Director of Marketing, Excerpt from INRIXIPI *Parking Professional* Article, November 2016

- The growing millennial population, in combination with rapidly improving technology, is the stimulus for this change. Vehicle miles traveled decreased from 2003-2014 in the United States, but as a former traffic commissioner of New York City noted: “It wasn’t because of the recession. It was millennials. They were driving 20-25% fewer miles. That was extraordinary, and the trend was that driving and parking (for millennials) was a hassle.” As vehicle miles started to decrease, innovative technology, digitization, increased connectivity, and the millennial generation began fueling the demand for smarter, more integrated driving experiences.
- We are now is an era of data-centricity, with complex technology and algorithms improving diagnostics, navigation and hybrid vehicles. Among the technological innovations surfacing in the auto industry right now are what we call ACES: autonomous, connected, electric and shared vehicles.
- By 2020, BI Intelligence (a research service from *Business Insider*), estimates that 75% of cars shipped globally will be equipped with Internet connectivity. That equates to more than 250 million connected cars on the road in just 4 years. Compared with 25 million connected cars in 2015. This movement toward connected services represents a significant shift in technological needs for the auto industry.
- As much as real-time traffic is now viewed as being a necessity, drivers in the near future will expect their cars to help them easily find the closest and cheapest available parking, compare prices and types, and pay conveniently and seamlessly.
- Connected vehicles transmit a wide range of data that can be collected and used to predict current parking availability on city streets and at off-street parking facilities. Cars equipped with light detection and ranging sensors, usually used to let you know if you are getting too close to objects in the road, can be used to detect where open parking spaces are located as you drive.
- According to analysts at Frost and Sullivan, searching for parking costs consumers and local economies nearly $600 million in wasted time and fuel every year. The connected car will affect every facet of the transportation, parking and city planning industries. This makes connecting every component of the parking ecosystem to cars an essential part of the path forward. If not, parking lots risk being invisible to drivers if they aren’t integrated in to the next generation of connected cars. Much as cities were unprepared for ridesharing services such as Uber and Lyft, we cannot overlook the importance of connected cars. A new study by the National League of Cities recently revealed that 94% of the world’s cities are not prepared to deal with autonomous cars.

Old models for managing urban transportation are insufficient. New options demand that we think in terms of mobility.

Stephen Goldsmith | Harvard University, Contributing author to *Governing* Magazine

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- Urban mobility is undergoing its starkest transformation since the first Model T rolled off the assembly line more than a century ago. Emerging services like car-, bike- and ride-sharing have provided city dwellers with a vast—and often confusing—array of options for getting around. And it’s too early to predict the impact of technologies that are on the horizon, such as driverless cars.
- Today’s changing needs demand that we find ways to bring together old and new modes of transportation so that they complement and enhance each other. With more and better data available now than ever before, we need to think in terms of true mobility management.

- That's a major departure from the traditional model in which cities or institutions might run a transportation department, a mass transit agency, a taxi commission and, perhaps in recent years, a bike-share program. That leaves individuals responsible for stitching together the various modes of transportation they need—car to bus, bus to train, train to bike and so on. As things stand, commuters can only make educated guesses about cost, duration and the likelihood of service availability and delays.
- In the new data-enabled, service-oriented model, government and institutional leaders will appoint mobility managers to enhance convenience and remove the transit deserts that plague many individuals who cannot afford cars and for whom inconveniently located bus routes provide little relief or for millennials who prefer the sharing economy approach as opposed to the vehicle ownership model of their parents. These mobility managers will help smooth transitions between public, private and shared transportation services. Individuals will be able to plan and pay for trips all in one place.

Urban Transportation's Multimodal Future: Networked alternatives for getting around are about to redefine our cities as much as the horseless carriage did a century ago.

Bob Graves | Associate Director of the Governing Institute

- The future, more and more urban transportation experts are coming to believe, lies in mobility-friendly networks in which cars are just one element—and an ever-shrinking one as we move from a system in which the personally owned vehicle is king and toward a multimodal future of on-demand driverless vehicles, ride-sharing, expanded public transit, greater reliance on human-powered transportation and other alternatives.
- How far could such a new mobility paradigm take us? Jerry Weiland, a 30-year veteran of General Motors who now leads the Rocky Mountain Institute's mobility program, believes that, over the long haul, the United States could reduce the number of urban/suburban vehicles on the road by up to 90% and in the process, redefine cities just as the horseless carriage once did.
- Whether or not this scenario plays out, it's clear that institutions and cities need a roadmap to guide the next generation of infrastructure investment decisions. Roads and bridges (and parking structures) last a long time, and new infrastructure is costly. What should city and institutional leaders be thinking about when they look at repositioning their infrastructure for the future? "The first thing cities and campuses should understand is that all of the transportation infrastructure is about networks, whether it's bike-share, whether it's light rail, whether it's roads," says Cooper Martin, co-author of a 2015 National League of Cities' report, **City of the Future: Technology & Mobility**. "One line, one bike-share station, one road doesn't cut it."
- Weiland says, "The new mobility has to offer people a complete answer, not a partial one. Otherwise you're not going to get rid of your car." It's safe to say that the best fail-safe alternative solution is a multimodal transportation system in which many options—bikes, transit, car- and ride-sharing—are readily available at a moment's notice along the direction of travel. With near real-time information, the traveler can seamlessly shift from one mode to another and choose the one most suited to his or her needs.
- Certainly, in rural communities—and no doubt many suburban ones—the personally owned car will remain the dominant transportation choice for some time. But in more urban settings, networked alternative transportation choices are already proving to be very dependable alternatives. With improving integration across transportation modes and seamless payment solutions, their growth is all but secured. Our mobility-friendly, multimodal urban transportation future may be closer that we realize.

Driverless Cars and the Disruptions They Will Bring: In planning for an autonomous-vehicle future, governments and institutions need to pay attention to the broader picture.

Bob Graves | Associate Director of the Governing Magazine

- It's easy to understand why the media is fascinated with autonomous vehicles. Scarcely a day goes by without another company's announcement of new driverless technology. The latest is Apple, which just received permission from the California Department of Motor Vehicles to test self-driving cars on the state's roadways. This brings the tally to 30 companies, not only the likes of Google and Tesla but also a long list of traditional automakers including BMW, Ford, GM, Honda, Mercedes-Benz, Nissan, Volkswagen and Subaru.

- However intriguing driverless cars may be conceptually, their integration into our transportation system will demand well informed and insightful planning. In response to this challenge, the Institute of Transportation Studies at the University of California, Davis last year launched its 3 Revolutions Policy Initiative to explore the impacts and synergies of vehicle automation along with two other disruptive technologies - electrification and vehicle sharing.
- The initiative's framing document lays out two possible future scenarios. In the first, in which the three emerging technologies are pursued in concert, "people have plentiful, accessible and affordable mobility options." We devote less precious space to parking; our air is cleaner and our communities are more livable. In the second scenario, governments allow car makers to rush gasoline-powered autonomous vehicles to market. Only the rich can afford them, and sprawl, traffic congestion and greenhouse-gas emissions worsen.
- Government planners will find Information generated from initiatives like this one critical. But there are signs that the private sector isn't likely to wait for government to exert its influence. Developers are already building what could be called "adaptable infrastructure."
- A case in point that is unfolding in Los Angeles, the nation's car capital, is described in a recent *Los Angeles Times* article. AvalonBay Communities Inc., one of the country's biggest developers, is designing a downtown residential complex for a future time when ride-sharing services and driverless cars whittle down car ownership and parking places become "expendable." Rather than building the traditional inclined floor garage, its level floors could be converted to "shops, a gym and a theater." The company also has been expanding the number of electric car charging stations in apartment complexes under construction and featuring prominent drop-off points for ride sharing.

A Big Makeover Is Coming to the Parking Garage of the Future Thanks to Autonomy: Autonomous cars will cause some substantial changes in how parking garages are designed

Urban Design Collaborative | Nashville, TN

- Back in January, Tesla Motors introduced "Summon," a feature that allows many of its newer vehicles to park themselves. Using a smartphone or key fob, car owners can remotely command their vehicles to open garage doors, enter, park themselves and shut down. When the cars are needed again, motorists can retrieve them in the same remote way.
- Other car companies are working on similar valet technologies, and the promise of cars that can park themselves is creating a ripple effect that stretches beyond the auto industry.
- Sometime later this year, excavators will start ripping into cement and construction crews will begin transforming 50 acres of an ordinary parking lot in a suburban Nashville office park into a future-minded space that brings together all the latest trends in urban planning.
- Developers intend to build a mix of retail spaces and residences that incorporate things like solar panels and green roofs. But that could describe any number of developments across the country. What makes this project most notable is that it's poised to include what is believed to be the nation's first parking structure designed for an era in which cars contain valet features like Summon and can park themselves and connect with broader transportation networks.
- Motorists might not think these drab structures would need to change in that transition. But like every other aspect of transportation being upended by technology, parking garages will be no different. Within the next two to five years, experts believe these technologies will begin to alter what drivers need from a parking garage. Further out, as that transition continues, existing structures may need to be retrofitted, and new ones rethought from the ground up. In Nashville, planners are trying to get a head start.
- "It's not even the clients pushing us, it's the investment group bringing the dollars to the table for the project, and they're saying, 'We need you to take this into consideration,'" said Brian Wright, founding Principal of Town Planning & Urban Design Collaborative, the company handling the Nashville project. "It really is a paradigm shift."

- Autonomous cars bring the likelihood that drop-off zones will be needed for vehicle occupants at the front of the buildings. Once occupants exit cars at a designated area, the cars can park themselves. And if there's no need for humans to exit parked cars, they can fit into narrower berths that may eventually shrink from a traditional 9-foot width to perhaps 7- or even 6.5-feet wide. Squeezing vehicles into tighter spaces in turn saves millions in costs for builders, home buyers and consumers alike. But that's just the small stuff.
- Connected cars add another dimension to the autonomous capabilities. Whether they're privately owned or shared vehicles, the ability to summon a ride remotely means garages may not even need to be located smack-dab in the middle of shopping districts or close to city centers. The garages can potentially be moved out of areas where real estate is at a premium. Not only does this mean big changes for parking garages, but big changes for the areas around them. Build too much parking, you generate traffic that congests your roadways.

It's Time to Think About Living in Parking Garages

Aarian March | LMN Architects, *Wired* Magazine, November 2, 2016

- The proposed 4th and Columbia project will include four floors of aboveground parking that can be converted to homes. The tower at 4th and Columbia will be the tallest in Seattle, a 1,029-foot, $290 million monument to the city's recent, tech-flavored success. Residential units, a hotel, office space, retail, eight floors of underground parking. Standard, shiny city stuff. And, if the current plans are approved, the tower will include a quirky twist: four levels of above-grade parking, designed to someday take on new life as apartments and offices.
- LMN Architects, which designed the project, wants the tower to survive 50 to 100 years. "If that's the case, we do need to make sure—I feel we do have the responsibility—that if the parking uses do change, we design to be able to adapt to that change," says John Chau, a partner at the firm. (The project is still moving through the city approval process, and will not be completed for another two to four years.)
- The change he's talking about is the coming transformation to a car-free-ish future. With rideshare, bikeshare, carshare, increasing transit options, and fully automated vehicles on the horizon, cities are less eager to allocate precious space for empty, parked cars. Already, places like Seattle have adjusted parking minimums, ditching rules that force developers to include parking for new projects near public transportation nodes.
- "A lot of people will start seeing a lot of these different shared services and say, 'OK, I don't actually need to own a car,'" says Scott Kubly, director of Seattle's Department of Transportation. (His family has relied on shared mobility services and transit since their personal car was totaled 10 months ago.)
- For the folks designing buildings to last decades or centuries, one way to prepare for that future is to consider life in the parking garage, laying the groundwork now for a retrofit to come. And Seattle's not the only city getting ready.

The Future of Mobility

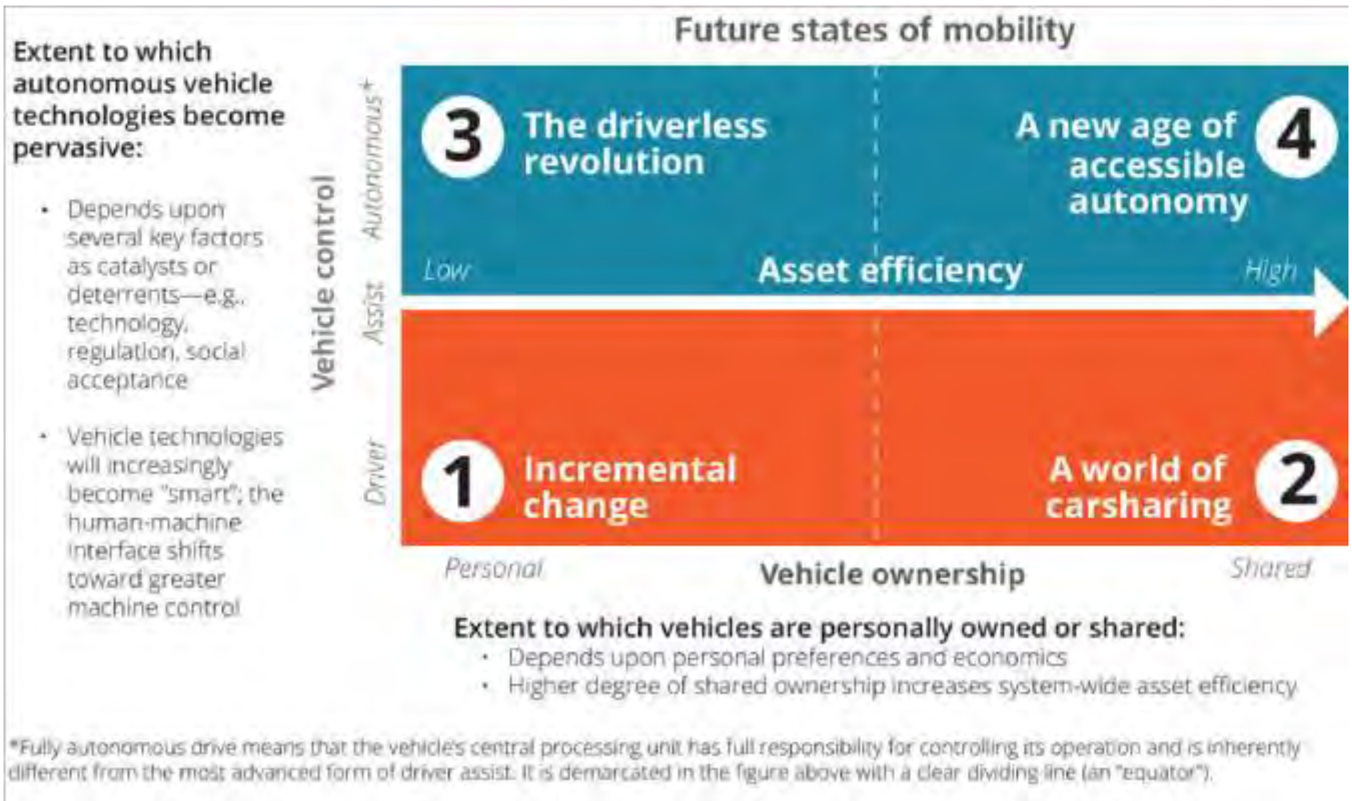
Deloitte Planning Series Article

- It is argued that four concurrent "future states" would emerge within the mobility ecosystem, emanating from the intersection of who owns the vehicle and who operates the vehicle: incremental change, a world of car sharing, the driverless revolution, and a new age of accessible autonomy (see illustration below).

    1. **Incremental Change:** This vision of the future sees private ownership remaining the norm as consumers opt for
    the forms of privacy, flexibility, security, and convenience that come with owning a vehicle. While incorporating driver-assist technologies, this future state assumes that fully autonomous drive doesn't completely displace driver-controlled vehicles anytime soon.
    2. **A World of Carsharing:** The second future state anticipates continued growth of shared access to vehicles through ridesharing and carsharing. Economic scale and increased competition drive the expansion of shared vehicle services into new geographic territories and more specialized customer segments. As shared mobility

serves a greater proportion of local transportation needs, multi-vehicle households can begin reducing the number of cars they own, while others may eventually abandon ownership altogether.

3. **The Driverless Revolution:** The third state is one in which autonomous drive technology* proves viable, safe, convenient, and economical, yet private ownership continues to prevail. Drivers still prefer owning their own vehicles but seek driverless functionality for its safety and convenience. This future will see a proliferation of highly customized, personalized vehicles catering to families or individuals with specific needs.
4. **A New Age of Autonomy:** The fourth future state anticipates a convergence of both the autonomous and vehicle sharing trends. Mobility management companies and fleet operators offer a range of passenger experiences to meet widely varied needs at differentiated price points. Taking off first in urban areas but spreading to the suburbs, this future state provides seamless mobility.



Graphic courtesy of Deloitte University Press (DUPress.com)

**Definition: By autonomy and autonomous vehicles (AV), we refer to stage 4 of the NHTSA's scale of autonomy—i.e., full self-driving automation in which the passengers are not expected to take control for the entire duration of travel.*

- **An Impending Transformation.** Our analysis suggests these changes could occur more quickly and at greater scale than many are prepared for, especially in densely populated areas. If shared and autonomous vehicles are adopted as quickly as other technologies (like smartphones, cellphones, and the Internet), our modeling finds that significant change will begin within five years and that the market for personal mobility could transform dramatically over the next 25 years (see Appendix for additional details). Population growth and the extension of transportation to the previously immobile, such as adolescents, elderly, lower-income groups, and those with disabilities, could cause total miles driven to increase by as much as 25% by 2040. Of course, if these services and technologies are adopted at slower rates more akin to electricity, the radio, or the television, the speed and magnitude of the changes will lessen accordingly and potentially significantly.

Future-Proofing Cities over the Next Decade for Driverless Cars

Leslie Braunstein | Urban Land Institute, May 25, 2017

- Driverless cars could reduce the need for up to half the nation's billion or so parking spaces over the next half century, freeing 3 million acres—an area the size of Connecticut—for development or green space to help cool overheated cities, noted ULI Global CEO Patrick Phillips during the conference's luncheon session
- Revathi Greenwood, director of research and analysis for CBRE suggests a timeline that has four stages as driverless cars become more autonomous:

– Technology development stage (2016-2020): licensed drivers with full legal responsibility for the vehicle required.

– Partial driver substitution (2020-2025): requirements for legally responsible drivers relaxed.

– Complete self-driving (2025-2029): vehicles can drive and park themselves, but drivers can intervene.

– Widespread adoption (2029 and beyond): cars are completely self-driven, and drivers have limited to no control.
Car ownership will shift to a "pay-per-mile" approach, and the U.S. economy will be significantly altered.

Mary Berra | CEO, General Motors

"The auto industry is poised for more change in the next five to ten years than it has seen in the past 50."

Autonomous Vehicle Implementation Predictions

The following section quotes extensively from Todd Litman's May 2017 white paper on "**Autonomous Vehicle Implementation Predictions: Implications for Transport Planning**".

Autonomous (also called self-driving, driverless, or robotic) vehicles have long been predicted in science fiction and discussed in popular media. Recently, major corporations have announced plans to begin selling such vehicles, and some jurisdictions have passed legislation to allow such vehicles to operate legally on public roads (Wikipedia 2013).

Levels of Autonomous Vehicles (NHTSA 2013)
Level1—Function-specific Automation Automation of specific control functions, such as cruise control, lane guidance and automated parallel parking. Drivers are fully engaged and responsible for overall vehicle control (hands on the steering wheel and foot on the pedal at all times).
Level 2 — Combined Function Automation Automation of multiple and integrated control functions, such as adaptive cruise control with lane centering. Drivers are responsible for monitoring the roadway and are expected to be available for control at all times, but under certain conditions can disengage from vehicle operation (hands off the steering wheel and foot off pedal simultaneously).
Level 3 — Limited Self-Driving Automation Drivers can cede all safety-critical functions under certain conditions and rely on the vehicle to monitor when conditions require transition back to driver control.
Level 4—Self-driving Under Specified Conditions Vehicles can perform all driving functions under specified conditions.
Level 5 — Full Self-Driving Automation System performs all driving functions on normal road types, speed ranges, and environmental conditions.

Much speculation surrounds autonomous vehicle impacts. Advocates predict that affordable, self-driving vehicles will greatly reduce traffic and parking costs, accidents and pollution emissions, and chauffeur non-drivers, reducing roadway costs and eliminating the need for conventional public transit services. In this scenario, the resulting savings will be so great that such vehicles will soon be ubiquitous and everyone will benefit. However, it is possible that their benefits will be smaller and their costs greater than these optimist predictions assume. Only recently have transportation practitioners explored how autonomous vehicles will affect planning decisions such as roadway design, parking costs, and public transit demand.

Estimated Benefits and Costs

Potential Benefits

Advocates predict that autonomous vehicles will provide significant user convenience, safety, congestion reductions, fuel savings, and pollution reduction benefits. Such claims may be overstated. For example, advocates argue that because driver error contributes to more than 90% of traffic accidents, self-driving cars will reduce crashes by 90%. If they feel safer, vehicle occupants may reduce seatbelt use, other road users may become less cautious, vehicles may operate faster and closer together, and human drivers may be tempted to join autonomous vehicle platoons, which will introduce new risks and enforcement requirements.

Estimated congestion and parking cost reductions, energy savings and emission reductions are also uncertain due to interactive effects. For example, the ability to work and rest while traveling may induce some motorists to choose larger vehicles that can serve as mobile offices and bedrooms ("commuter sex" may be a marketing strategy) and drive more annual miles. Self-driving taxis and self-parking cars may increase empty vehicle travel. Although the additional vehicle travel provides user benefits (otherwise, users would not increase their mileage) it can increase external costs, including congestion, roadway and parking facility costs, accident risk imposed on other road users, and pollution emissions. Strategies, such as platooning, may be limited to grade-separated roadways, increasing congestion on surface streets by human-driven vehicles. Autonomous vehicles may also reduce public transit travel demand, leading to reduced service and stimulating more sprawled development patterns which reduce transport options and increase total vehicle travel.

Potential Costs

The incremental costs of producing autonomous vehicles are uncertain. AVs require a variety of special sensors, computers, and controls, which currently are expensive but likely to become cheaper with mass production. Because system failures could be fatal to both vehicle occupants and other road users, all critical components will need to meet high manufacturing, installation, repair, testing, and maintenance standards, similar to aircraft components, and so will probably be relatively expensive. Autonomous vehicle operation may require special navigation and mapping service subscriptions (which explains Google Corporation's interest in this technology). Simpler technologies still add hundreds of dollars to vehicle retail prices.

For example, GPS and telecommunications systems, review cameras, and automatic transmissions typically cost $500 to $2,000. Navigation and security services such as OnStar and TomTom have $200 to $350 annual fees. Autonomous vehicles require these plus other equipment and services (see box below).

Autonomous Vehicle Equipment and Service Requirements
Automatic transmissions.
Diverse and redundant sensors (optical, infrared, radar, ultrasonic and laser) capable of operating in diverse conditions (rain, snow, unpaved roads, tunnels, etc.).
Wireless networks. Short range systems for vehicle-to-vehicle communications, and long-range systems to access maps, software upgrades, road condition reports, and emergency messages.
Navigation, including GPS systems and special maps.
Automated controls (steering, braking, signals, etc.) Servers, software, and power supplies with high reliability standards.
Additional testing, maintenance, and repair costs for critical components, such as sensors and controls.

Manufacturers will need to recover costs for development, ongoing service (special mapping and software upgrades) and liability, while earning a profit. This suggests that when technology is mature, self-driving capability will probably add several thousand dollars to vehicle purchase prices, plus a few hundred dollars in annual service costs, adding $1,000 to $3,000 to annual vehicle costs. These incremental costs may be partly offset by fuel and insurance savings averaging approximately $2,000 for fuel and $1,000 for insurance per vehicle-year. If autonomous vehicles reduce fuel consumption by 10% and insurance costs by 30%, the annual savings will total about $500, which will not fully offset predicted incremental annual costs.

Autonomous vehicles can be programmed to optimize occupant comfort. Some argue that because vehicle passengers tend to be more sensitive to acceleration than drivers, and occupants use travel time to work or rest (autonomous vehicle illustrations often show occupants playing cards or sleeping), it is plausible that users will program their vehicle for slower acceleration/deceleration characteristics than human powered vehicles, leading to reduced urban roadway capacity.

Shared Vehicles

Some advocates claim that self-driving capabilities will result in more vehicle sharing, including self-driving taxis and more private vehicle ridesharing. Estimates show that by allowing household vehicles to serve multiple residents, for example, taking a commuter to work and then transporting another household member for errands, vehicle ownership could be reduced by up to 43% and travel per vehicle increased by up to 75%, but these impacts are difficult to predict. There are many reasons that motorists may prefer a personal rather than shared vehicle—keeping tools or carrying dirty loads, because driving many annual miles, needing assistance provided by human drivers, or simply, for status. Autonomous taxis are likely to incur these additional costs:

- **Vehicle travel to trip origins.** This may be a modest cost in dense urban areas where taxis are widely distributed, but likely to add 10-20% to total vehicle travel in lower-density suburban and rural areas or for specialized vehicles, such as vans and trucks.
- **Cleaning and vandalism.** Taxis and public transit vehicles require frequent cleaning when passengers litter, smoke, or spill food and drinks, and repairs when vehicles are vandalized. To minimize these risks, self-driving taxis will need hardened surfaces, electronic surveillance, and aggressive enforcement. Assuming such vehicles make 200 weekly trips, 5-15% of passengers leave messes with $10-30 average cleanup costs, and 1-4% vandalize vehicles with $50-100 average repair costs, these costs would average between $200 and $1,700 per vehicle-week.
- **Reduced services.** Drivers often help passengers (particularly those with disabilities) in and out of taxis, carry luggage, ensure passengers safely reach destinations, and offer guidance to visitors.
- **Reduced comfort and privacy.** Vehicles designed to minimize cleaning and vandalism risks will probably have less comfort (no leather upholstery or carpeted floors), fewer accessories (limited sound systems), and less reliability (since vehicles will frequently need cleaning and repairs) than personal vehicles. Passengers will need to accept that their activities will be recorded.

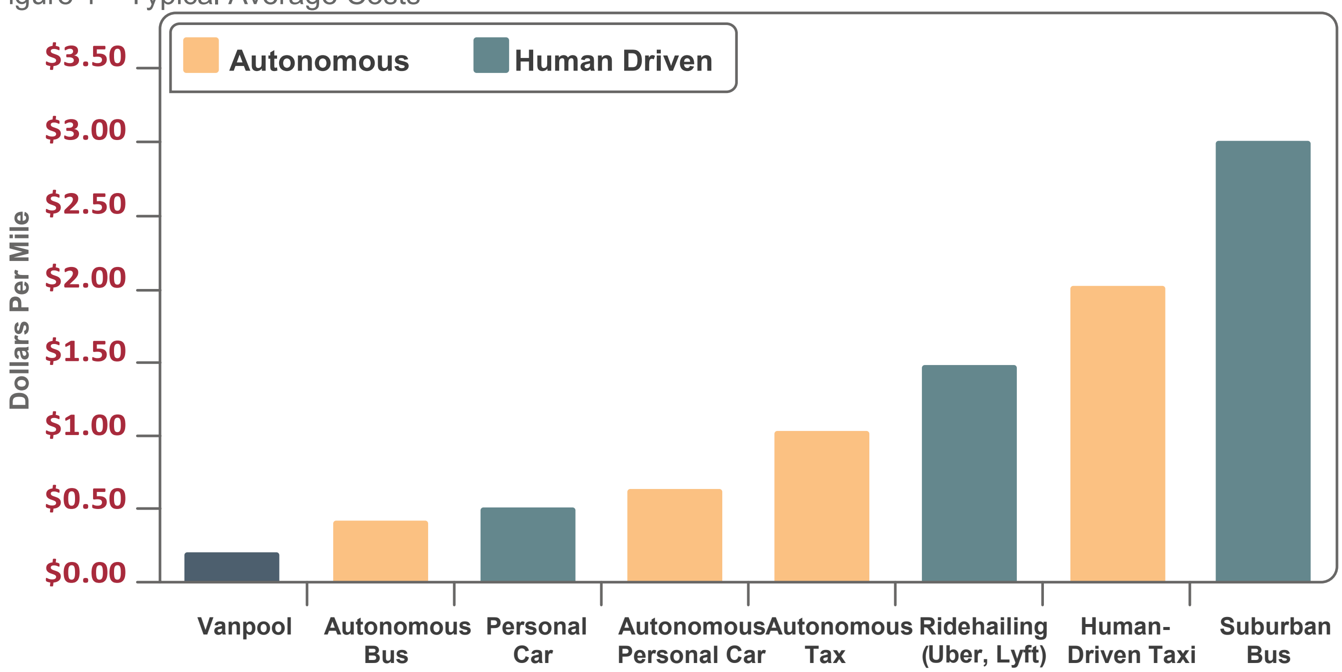
Personal automobiles typically cost about $4,000 annually in fixed expenses plus 20¢ per mile in operating costs. It is generally cheaper to use conventional taxis ($2-3 per mile) rather than own a personal vehicle driven less than about 2,500 annual miles, or rely on carsharing services ($60¢-$1 per mile) rather than own a vehicle driven less than about 6,000 annual miles. This suggests that autonomous vehicles will be a cost-effective alternative to owning a vehicle driving less than 2,500 to 6,000 annual miles, depending on cleaning and repair costs. **Table 1** summarizes trip types most suitable for self-driving taxis, a minority of total vehicle travel. Because of these additional costs, and reduced passenger comfort and privacy, it seems unlikely that most motorists will shift from owning vehicles to relying on self-driving taxis.

Table 1—Likely Uses of Self-Driving Taxis	
Suitable Uses	**Unsuited Uses**
Trips currently made by taxi or carshare vehicles. Utilitarian trips currently made by a private vehicle driven less than 6,000 annual miles.	Motorists who take pride in vehicles or value extra comfort. Motorists who drive more than 6,000 annual miles. Motorists who require special accessories in their vehicles. Motorists who often carry tools or dirty loads. Passengers who want assistance getting in and out of taxis. Passengers who place high values on privacy.

Self-driving taxis may allow some motorists to reduce their vehicle ownership, but impacts are likely to be modest and will depend on factors such as cleaning and vandalism costs, user comfort, and privacy.

Various studies have estimated that shared autonomous vehicles will cost $0.20-0.40 per passenger-mile (Bösch, et al. 2017), but these are mostly lower estimates that exclude some cost categories (such as vehicle cleaning, administration, and profits), use optimistic cost and occupancy assumptions, and ignore empty vehicle travel required for taxi services. A more realistic estimate for shared autonomous vehicle costs is likely to range from carsharing ($0.60- $1.00 per vehicle-mile, including ownership, operation and administrative costs) to human-operated taxis ($2.00-3.00 per vehicle-mile, including ownership, operation, administration and labor costs). Autonomous taxis will probably cost more per passenger-mile than transit bus service under urban conditions, but less than under suburban conditions.

Figure 1—Typical Average Costs



Vehicle costs vary depending on type, occupancy and travel conditions. Autonomous vehicles will cost somewhat more than human-powered cars, due to additional equipment and navigation systems required, but can offer somewhat cheaper taxi and bus services than those that are human-powered.

Impacts on Total Vehicle Travel

Table 2 lists various ways that autonomous vehicles can affect total vehicle travel (vehicle miles traveled or VMT). Although it is difficult to predict how these factors will interact, many studies suggest that by making vehicle travel more convenient, autonomous vehicles are likely to increase total vehicle travel unless specific demand management strategies are implemented, such as higher road user fees (Smith 2012). Trommer, et al. (2016) estimates that autonomous vehicles are likely to increase total vehicle travel 3-9% by 2035.

Table 2—Autonomous Vehicle Impacts on Total Vehicle Travel

Increases Vehicle Travel	**Reduces Vehicle Travel**
More convenient and productive travel (passengers can rest and work) will reduce travel time costs, stimulating more vehicle travel. Provides convenient vehicle travel to non-drivers (people too young, old, disabled, impaired, or otherwise lacking a drivers' license. Sivak and Schoettle (2015c) estimate that, accommodating non-drivers' latent travel demands could increase total vehicle by up to 11%. Self-driving taxis will travel more for empty back hauls. Can make sprawled, automobile-dependent locations more attractive. Reduces traffic congestion and vehicle operating costs, which induces additional vehicle travel.	More convenient shared vehicles allows households to reduce total vehicle ownership and use. Increases vehicle ownership and operating costs, further reducing private vehicle ownership. Self-driving transit vehicles improve transit services. Reduced pedestrian risks and parking demands makes urban living more attractive. Reduce some vehicle travel, such as cruising for parking spaces.

Self-driving vehicles can affect total vehicle travel (VTM) in various ways.

These scenarios illustrate how autonomous vehicles could impact various users travel patterns:

Jake is an affluent man with degenerating vision. In 2026, his doctor convinced him to give up driving. He purchases an autonomous vehicle instead of walking, transit, and taxis.

Impacts: An autonomous vehicle allows Jake to continue using a car, which increases his independent mobility, total vehicle ownership and travel, residential parking demand, and external costs (congestion, roadway costs, parking subsidies, and pollution emissions), compared with what would otherwise occur.

Bonnie lives and works in a suburb. She can bike to most destinations but occasionally needs to travel by car. In a city, she could rely on taxis and carsharing but such services are slow and expensive in suburbs. In 2030, a local company started offering fast and affordable automated taxi services.

Impacts: Autonomous vehicles allow Bonnie to rely on shared vehicles rather than purchase a car, which reduces her total vehicle travel, residential parking demand, and external costs.

Malisa and Johnny have two children. Malisa works at a downtown office. After their second child was born in 2035, they shopped for a larger home. With conventional cars, they would only consider houses within a 30-minute drive of the city. More affordable autonomous vehicles allowed them to consider more distant homes, with commutes up to 60-minutes, during which Malisa could rest and work.

Impacts: Affordable new autonomous vehicles allow Malisa and Johnny to choose an exurban home which increased their total vehicle travel and associated costs, plus other costs caused by sprawl.

Garry is hardworking and responsible when sober, but a dangerous driver when drunk. By 2040, he has accumulated several impaired citations and caused a few accidents. With conventional cars, Garry would continue driving impaired until he lost his drivers' license or caused a severe crash, but affordable used self-driving vehicles allow lower-income motorists like Garry to avoid such problems.

Impacts: Affordable used autonomous vehicles allow Garry to avoid impaired driving, accidents and revoked driving privileges, which reduces crash risks but increases his vehicle ownership and travel, and external costs compared with what would otherwise occur.

Table 3 summarizes the resulting impacts of these various scenarios. This suggests that in many cases autonomous vehicles will increase total vehicle mileage.

Table 3—Autonomous Vehicle Scenario Summary

	User Benefits	**Travel Impacts**	**Infrastructure Impacts**
Jake	Independent mobility for nondrivers	Increased vehicle travel and external costs	Increased residential parking and roadway costs
Bonnie	Vehicle cost savings	Reduced vehicle ownership and travel	Reduced residential parking and roadway costs
Malisa & Johnny	Improved home location options	Increased vehicle ownership and travel	Increased residential parking and roadway costs
Garry	Avoids driving drunk and associated consequences	Less high-risk driving, more total vehicle travel	Increased residential parking and roadway costs

Autonomous vehicle availability can have various direct and indirect impacts.

This analysis suggests that effects which increase motor vehicle travel are more numerous and significant than those that reduce vehicle travel. With that in mind, self-driving vehicles are likely to increase total vehicle travel, although these impacts are difficult to predict and will depend on specific autonomous vehicle implementation, such as their actual performance and user costs as well as other factors that affect vehicle travel such as fuel and road prices. Increases in total vehicle travel may be somewhat offset by reductions in per-mile costs of this incremental travel. For example, self-driving cars may impose less traffic congestion, parking costs, accident risk, and air pollution costs than human-operated vehicles per mile traveled which would counter the increased vehicle travel costs although the net effects are uncertain.

Summary of Benefits and Costs

Table 4 summarizes expected autonomous vehicle benefits and costs.

Table 4—Autonomous Vehicle Potential Benefits and Costs

Benefits	Costs/Problems
Reduced driver stress. Reduce the stress of driving and allow motorists to rest and work while traveling.	***Increases costs.*** Requires additional vehicle equipment, services and maintenance, and possibly roadway infrastructure.
Reduced driver costs. Reduce costs of paid drivers for taxis and commercial transport.	*Additional risks.* May introduce new risks, such as system failures, be less safe under certain conditions, and encourage road users to take additional risks (offsetting behavior).
Mobility for non-drivers. Provide independent mobility for non-drivers, and therefore reduce the need for motorists to chauffeur non-drivers, and to subsidize public transit.	***Security and Privacy concerns.*** May be used for criminal and terrorist activities (such as bomb delivery), vulnerable to information abuse (hacking), and features such as GPS tracking and data sharing may raise privacy concerns.
Increased safety. May reduce many common accident risks and therefore crash costs and insurance premiums. May reduce high-risk driving, such as when impaired.	***Induced vehicle travel and increased external costs.*** By increasing travel convenience and affordability, autonomous vehicles may induce additional vehicle travel, increasing external costs of parking, crashes and pollution.
Increased road capacity, reduced costs. May allow platooning (vehicle groups traveling close together), narrower lanes, and reduced intersection stops, reducing congestion and roadway costs.	***Social equity concerns.*** May have unfair impacts, for example, by reducing other modes' convenience and safety.
More efficient parking, reduced costs. Can drop off passengers and find a parking space, increasing motorist convenience and reducing total parking costs.	***Reduced employment and business activity.*** Jobs for drivers should decline, and there may be less demand for vehicle repairs due to reduced crash rates.
Increase fuel efficiency and reduce pollution. May increase fuel efficiency and reduce pollution emissions.	***Misplaced planning emphasis***. Focusing on autonomous vehicle solutions may discourage communities from implementing more cost-effective transport solutions such as better walking and transit improvements, pricing reforms and other demand management strategies.
Supports shared vehicles. Could facilitate carsharing (vehicle rental services that substitute for personal vehicle ownership), which can provide various savings.	

Autonomous vehicles can provide various benefits and impose various costs.

Some impacts, such as reduced driver stress and increased urban roadway capacity, can occur under level 2 or 3 implementation, which provides limited self-driving capability, but many benefits, such as significant crash reductions, road and parking cost savings and affordable mobility for non-drivers, require that level 4 vehicles become common and inexpensive.

Development and Deployment

Table 5 summarizes the likely stages of autonomous vehicle development and deployment.

Table 5—Autonomous Vehicle Implementation Stages
(Wikipedia 2013; NHTSA 2013)

Stage	Notes
Level 2—Limited automation (steering, braking and lane guidance)	Current state of art technology, available on some vehicles.
Coordinated platooning	Currently technically feasible but requires vehicle-to-vehicle communications capability, and dedicated lanes to maximize safety and mobility benefits.
Level 3—Restricted self-driving	Currently being tested. Google experimental cars have driven hundreds of thousands of miles in self-drive mode under restricted conditions.
Level 4—Self-driving in all conditions	Requires more technological development.
Regulatory approval for automated driving on public roadways.	Some states have started developing performance standards and regulations that autonomous vehicles must meet to legally operate on public roads.
Fully-autonomous vehicles available for sale.	Several companies predict commercial sales of “driverless cars” between 2018 and 2020, although their capabilities and prices are not specified.
Autonomous vehicles become a major portion of total vehicle sales.	Will depend on performance, prices and consumer acceptance. New technologies usually require several years to build market acceptance.
Autonomous vehicles become a major portion of vehicle fleets.	As the portion of new vehicles with autonomous driving capability increases, their portion of the total vehicle fleet will increase over a few decades.
Autonomous vehicles become a major portion of vehicle travel.	Newer vehicles tend to be driven more than average, so new technologies tend to represent a larger portion of vehicle travel then the vehicle fleet.
Market saturation.	Everybody who wants an autonomous vehicle has one.
Universal	All vehicles operate autonomously.

Autonomous vehicle implementation will involve several phases.

As of 2016, many new vehicles have some level 1 automation features, including cruise control, obstruction warning, and parallel parking. Some manufactures, such as Tesla, now offer level 2 features such as automated lane guidance, accident avoidance, and driver fatigue detection. Coordinated platooning is now technically feasible but not operational because many benefits require dedicated lanes. Google’s level 3 test vehicles have reportedly driven hundreds of thousands of miles under restricted conditions, including specially mapped routes, fair weather, and human drivers able to intervene when needed (Muller 2013). Some manufacturers aspire to sell level 4 automation vehicles within a few years but details are uncertain; early versions will probably be limited to controlled environments, such as freeways (Row 2013).

Despite this progress, significant technical improvement is needed to achieve unrestricted level 4 operation (Simonite 2016). Since a failure could be deadly to vehicle occupants and other road users, automated driving has high performance requirements. Sensors, computers, and software must be robust, redundant, and resistant to abuse. Several more years of development and testing will be required before regulators and potential users gain confidence that level 4 vehicles can operate as expected under all conditions (Bilger 2013; Schoettle and Sivak 2015).

Implementation Projections

Autonomous vehicle implementation can be predicted based on the pattern of previous vehicle technologies, and vehicle fleet turnover rates.

- **Automatic Transmissions** (Healey 2012). First developed in the 1930s, automatic transmissions were not reliable and affordable until the 1980s. Now standard on most U.S. medium and high-priced vehicles, although some models have manual mode. When optional, they typically cost $1,000 to $2,000. Current vehicle market shares are about 90% in North America and 50% in Europe and Asia.
- **Air Bags** (Dirksen 1997). First introduced in 1973, this feature was initially an expensive and sometimes dangerous option (they could cause injuries and deaths). As air bags became cheaper and safer, they became standard on some models starting in 1988, and mandated by U.S. federal regulation in 1998.
- **Hybrid Vehicles** (Berman 2011). Commercially available in 1997, the prices of these vehicles were high and the performance was poor. Their performance and usability has improved but typically add about $5,000 to vehicle prices. In 2012, they represented about 3.3% of total vehicle sales.
- **Subscription Vehicle Services.** Navigation, remote lock/unlock, diagnostics, and emergency services. OnStar became available in 1997, TomTom in 2002. These systems typically cost $200-400 annually. About 2% of U.S. motorists subscribe to the largest service, OnStar.
- **Vehicle Navigation Systems** (Lendion 2012). Vehicle navigation systems became available as expensive accessories in the mid-1980s. In the mid-1990s, factory-installed systems became available on some models for about $2,000. Performance and usability have since improved, and prices have declined to about $500 for factory-installed systems and under $200 for portable systems. They are standard in many higher-priced models.

Table 6 summarizes the deployment cycles for these technologies—from first commercial availability to market saturation. Most technologies require decades of development and market growth to saturate their potential markets and, in many cases, never become universal. Airbags had the shortest cycle and the most complete market share due to federal mandates. Automatic transmissions required more than five decades for prices to decline and quality to improve, but are still not universal. Hybrid vehicles are still developing after 15 years on the market, have substantial price premiums, and modest market share. This suggests that new vehicle technologies generally require two to five decades from commercial availability to market saturation, and will not become universal without government mandates.

Table 6—Vehicle Technology Deployment Summary

Name	Deployment Cycle	Typical Cost Premium	Market Saturation Share
Air bags	25 years (1973-1998)	A few hundred dollars	100%, due to federal mandate
Automatic transmissions	50 years (1940s-1990s)	$1,500	90% U.S., 50% worldwide
Navigation systems	30+ years (1985-2015+)	$500 and rapidly declining	Uncertain; probably over 80%
Optional GPS services	15 years	$250 annual	2-5%
Hybrid vehicles	25+ years (1990s-2015+)	$5,000	Uncertain. Currently about 4%

New technologies usually require several decades between commercial availability to market saturation.

Modern vehicles are durable, resulting in slow fleet turnover. Median operating lives increased from 11.5 years for the 1970 model year, to 12.5 years for the 1980 model year, and 16.9 years for the 1990 model year (ORNL 2012, Table 3.12), suggesting that current vehicles may have 20-year or longer average lifespans. As a result, new vehicle technologies normally require three to five decades to be implemented in 90% of operating vehicles. Deployment may be faster in developing countries where fleets are expanding, and in areas with strict vehicle inspection requirements, such as Japan's shaken system. Annual mileage tends to decline as vehicles age. For example, 2001 vehicles averaged approximately 15,000 miles their first year, 10,000 miles their 10th year, and 5,000 miles their 15th year. Vehicles older than ten years represent about 50% of the vehicle fleet but only about 20% of vehicle mileage (ORNL 2012, Table 3.8).

As previously described, autonomous driving capability will probably increase vehicle purchase prices by thousands of dollars, and may require hundreds of dollars in annual subscription fees for special navigation and mapping services. Although self-driving vehicles may provide large benefits to some users (high-income non-drivers, long-distance automobile commuters, and commercial drivers), it is unclear what portion of motorists will consider the benefits worth the additional costs. A recent consumer survey found general support for the concept, but also significant concerns about privacy and safety, and relatively low willingness to pay extra for self-driving capability features (Schoettle and Sivak 2014).

Table 7 summarizes projected autonomous vehicle implementation rates based on previous vehicle technology deployment. This assumes that fully-autonomous vehicles are available for sale and legal to drive on public roads around 2020. As with previous vehicle technologies, these AVs will be imperfect initially (poor reliability and performance, and difficult to operate) and costly (tens of thousands of dollars in price premiums). As such, they will represent a small portion of total vehicle sales, with market share increasing during subsequent decades as their performance improves, prices decline, and benefits are demonstrated. Over time they will increase as a share of total vehicle fleets. Since newer vehicles are driven more than average annual miles, their share of vehicle travel is proportionately large. Without mandates, deployment will probably follow the pattern of automatic transmissions, which took nearly five decades to reach market saturation, and a portion of motorists continue to choose manual transmissions due to personal preferences and cost savings.

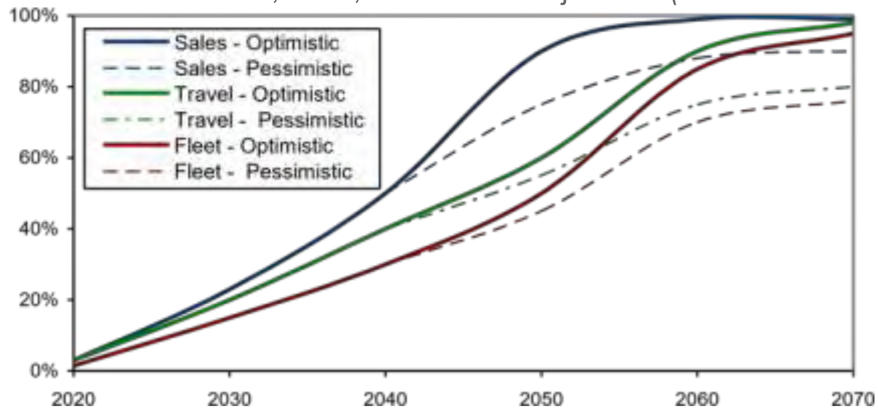
Table 7—Autonomous Vehicle Implementation Projections

Stage	Decade	Vehicle Sales	Vehicle Fleet	Vehicle Travel
Available with large price premium	2020s	2-5%	1-2%	1-4%
Available with moderate price premium	2030s	20-40%	10-20%	10-30%
Available with minimal price premium	2040s	40-60%	20-40%	30-50%
Standard feature included on most new vehicles	2050s	80-100%	40-60%	50-80%
Saturation (everybody who wants it has it)	2060s	?	?	?
Required for all new and operating vehicles	???	100%	100%	100%

Autonomous vehicle implementation will probably take several decades.

Figure 2 illustrates the deployment rates from Table 6. If accurate, in the 2040s autonomous vehicles will represent approximately 50% of vehicle sales, 30% of vehicles, and 40% of all vehicle travel in the 2040s. Only in the 2050s would most vehicles be capable of automated driving.

Figure 2—Autonomous Vehicle Sales, Fleet, and Travel Projections *(based on Table 6)*



If autonomous vehicle implementation follows the patterns of other vehicle technologies, it will take one to three decades to dominate vehicle sales, plus one or two more decades to dominate vehicle travel. Even at market saturation, it is possible that a significant portion of vehicles and vehicle travel will continue to be self-driven, indicated by the dashed lines.

Autonomous vehicle implementation could be even slower and less complete than these predictions. Technical challenges may be more difficult to solve than expected, so fully self-driving vehicles may not be commercially available until the 2030s or 2040s. They may have higher than expected production costs and retail prices, their benefits may be smaller and problems greater than predicted, and technical constraints, privacy concerns, and personal preference may reduce consumer acceptance, resulting in a significant portion of vehicle travel remaining human-driven even after market saturation.

Significantly faster implementation would require much faster development, deployment, and fleet turnover than previous vehicle technologies. For example, for the majority of vehicle travel to be autonomous by 2035, most new vehicles purchased after 2025 would need to be autonomous. New vehicle purchase rates would need to triple allowing the fleet turnover process that normally takes three decades to occur in one. This would require most low- and middle-income motorists, who normally purchase used vehicles or cheaper new models, to spend significantly more to purchase an automobile with self-driving capability. As a result, many otherwise functional vehicles be scrapped just because they lack self-driving capability.

Planning Implications

Autonomous vehicle implementation is just one of several factors likely to affect future transport demands and costs, as illustrated in Figure 3. Demographic trends, changing consumer preferences, price changes, improving transport options, improved user information, and other planning innovations will also influence how and how much people drive. These may have greater planning impacts than autonomous vehicles, at least until the 2040s.

Figure 3—Factors Affecting Transport Demands and Costs

Autonomous vehicles are one of many factors that will affect transport demands and costs in the next few decades, and not necessarily the most important.

DEMOGRAPHIC TRENDS	PRICE CHANGES	IMPROVED TRAVEL OPTIONS
Aging population More working at home Reduced youth driver's license	Rising fuel prices Efficient road & parking pricing	Better walking and cycling Improved public transit Telework and delivery services Car sharing
CHANGING USER PREFERENCES	**INTELLIGENT TRANSPORT SYSTEMS (ITS)**	**PLANNING INNOVATIONS**
Less driving Shared rather than personal cars More walking & cycling More urban living	Improved information navigation Electronic pricing Autonomous vehicles	Expanded objectives Systems operations Demand management

Table 8 summarizes the functional requirements and planning implications of various autonomous vehicle impacts and their expected time period based on Table 5 projections. This suggests that during the 2020s and 2030s, transport planners and engineers will be primarily concerned with defining autonomous vehicle performance, testing, and reporting requirements for operation on public roadways. If several years of testing demonstrate autonomous vehicle benefits, transport professionals may support policies that encourage or require self-driving capability in new vehicles.

Parking requirements may be reduced when AVs can provide convenient and inexpensive taxi and carsharing services, reduce the need for conventional public transit services, allow more households to rely on such services, and reduce vehicle ownership. However, modeling by the International Transport Forum indicates that self-driving taxis and public transit services are complements rather than substitutes. Transit is more efficient at serving many peak period urban trips which would significantly reduce the self-driving taxi fleet size and costs.

Some benefits (higher traffic speeds, reduced congestion, and automated intersections) require dedicated autonomous vehicle lanes. This will raise debates about fairness and cost efficiency, and human drivers may be tempted to use such lanes. For example, following a platoon of self-driving vehicles would introduce new risks, regulations, and enforcement requirements, probably starting in the 2030s.

Table 8—Autonomous Vehicle Planning Impacts By Time Period			
Impact	**Functional Requirements**	**Planning Impacts**	**Time Period**
Become legal	Demonstrated functionality and safety	Define performance, testing, and data collection requirements for automated driving on public roads.	2015-25
Increase traffic density by vehicle coordination	Road lanes dedicated to vehicles with coordinated platooning capability	Evaluate impacts. Define requirements. Identify lanes to be dedicated to vehicles capable of coordinated operation.	2020-40
Independent mobility for non-drivers	Fully autonomous vehicles available for sale	Allows affluent non-drivers to enjoy independent mobility.	2020-30s
Automated carsharing/taxi	Moderate price premium. Successful business model.	May provide demand response services in affluent areas. Supports carsharing.	2030-40s
Independent mobility for lower-income	Affordable autonomous vehicles for sale	Reduced need for conventional public transit services in some areas.	2040-50s
Reduced parking demand	Major share of vehicles are autonomous	Reduced parking requirements.	2040-50s
Reduced traffic congestion	Major share of urban peak vehicle travel is autonomous.	Reduced road supply.	2050-60s
Increased safety	Major share of vehicle travel is autonomous	Reduced traffic risk. Possibly increased walking and cycling activity.	2040-60s
Energy conservation and emission reductions	Major share of vehicle travel is autonomous. Walking and cycling become safer.	Supports energy conservation and emission reduction efforts.	2040-60s
Improved vehicle control	Most or all vehicles are autonomous	Allows narrower lanes and interactive traffic controls.	2050-70s
Need to plan for mixed traffic	Major share of vehicles are autonomous.	More complex traffic. May justify restrictions on human-driven vehicles.	2040-60s
Mandated	Most vehicles are autonomous and large benefits are proven.	Allows advanced traffic management.	2060-80s

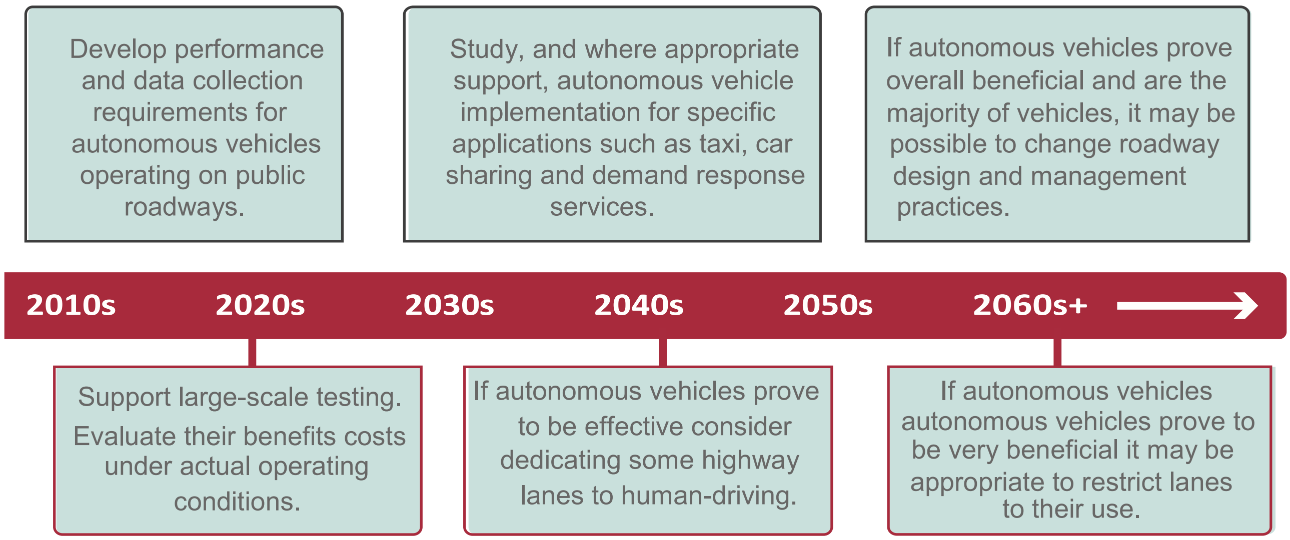
Autonomous vehicles will have various impacts on transportation planning.

When autonomous vehicles become a major share of total vehicle travel they may significantly reduce traffic risk and congestion, and parking problems, while providing some energy savings and emission reductions. Transportation professionals will be involved in technical analyses to determine their actual benefits and policy debates concerning whether public policies should encourage or require autonomous vehicles.

These impacts may vary geographically, with more rapid implementation in areas that are more affluent (residents can more quickly afford autonomous vehicles), more congested (potential benefits are greater), and have more public support.

The timeline in Figure 4 summarizes autonomous vehicle planning impact projections.

Figure 4—Autonomous Vehicle Planning Impacts Timeline



This timeline summarizes how autonomous vehicles are likely to impact transport planning.

An Analogy: Automated Banking Services

Personal computers first became available for purchase during the 1970s, the Internet went public in the 1980s, automated teller machines (ATMs) became common in the 1990s, most households were using the Internet for personal business activities by the 2000s. Similarly, banks have encouraged customers to use central call centers rather than local offices to answer questions for decades, yet these technologies have not eliminated the need for local banks with human tellers.

Automated banking can reduce the number of branch offices and employees, but customers often prefer to interact with human tellers because it can be faster and less frustrating, and therefore, more productive than automated, Internet, or telephone options. Automation has had evolutionary rather than revolutionary impacts on bank activities. Other trends—banking services, changing regulations, and management practices—have equal or greater impacts on bank infrastructure planning.

Autonomous vehicle implementation will probably follow similar patterns. Deployment will take several decades, is unlikely to totally displace current technology, will have costs as well as benefits, and will only marginally affect infrastructure planning for the foreseeable future. It is one of several current trends likely to affect road, parking, and transit demands, and these changes will probably occur gradually over several decades.

Conclusions

Recent announcements that autonomous vehicles have safely driven hundreds of thousands of miles and that major manufactures aspire to soon sell such vehicles coupled with optimistic predictions of their benefits, have raised hopes that this technology will soon be widely available and solve many transportation problems. However, there are good reasons to be cautious when predicting their future role.

There is considerable uncertainty concerning autonomous vehicle benefits, costs, and travel impacts. Advocates claim that they will provide large benefits that offset costs, but will require additional equipment, services, and maintenance costs that will likely total hundreds or thousands of dollars per vehicle-year. Moreover, many of their benefits are unproven.

Current automated vehicles can only self-drive under limited conditions. Significant technical and economic obstacles must be overcome before most households can rely on AVs for daily travel. Operating a vehicle on public roads is more complex than flying an airplane due to the frequency and proximity of interactions with often unpredictable objects, including other vehicles, pedestrians, animals, buildings, trash, and potholes. If AVs follow previous vehicle technology deployment patterns, autonomous vehicles will initially be costly and imperfect. During the 2020s and perhaps the 2030s, autonomous vehicles are likely to be expensive novelties with limited abilities, such as restrictions on the road conditions in which they may operate. It will probably be the 2040s or 2050s before middle-income families can afford to own self-driving vehicles that safely operate in all conditions, and even longer before used autonomous vehicles become affordable to lower-income households. A significant portion of motorists may resist such vehicles, just as some motorists prefer manual transmissions, resulting in mixed traffic that creates new roadway management problems.

Vehicle innovations tend to be implemented more slowly than other technological changes due to their high costs, slow fleet turnover, and strict safety requirements. Automobiles typically cost 50 times as much and last ten times as long as mobile phones and personal computers. As such, consumers seldom purchase new vehicles just to obtain a new technology. Autonomous vehicles will likely have relatively costly equipment and service standards, similar to airplanes, which may discourage some users. Large increases in new vehicle purchases and scrappage rates would be required for most vehicles to be autonomous before 2050.

Self-driving taxi costs are likely to range between carsharing ($0.60-1 per mile) and human driven taxis ($2-3 per mile), depending on factors, such as their cleaning costs. This will make them a cost-effective alternative to owning lower mileage (5,000 annual miles) vehicles. However, many motorists are likely to prefer owning personal vehicles for prestige and convenience sake. As a result, shared autonomous vehicles are likely to reduce vehicle ownership mostly in compact, multimodal urban areas, and will have little effect in suburban and rural areas.

Advocates may exaggerate net benefits by ignoring new costs and risks, offsetting behavior (the tendency of road users to take additional risks when they feel safer), rebound effects (increased vehicle travel caused by faster travel or reduced operating costs, which may increase external costs), and harms to people who do not to use the technology, such as reduced public transit service. Benefits are sometimes double-counted by summing increased safety, traffic speeds, and facility savings, although there are trade-offs between them.

Transportation professionals (planners, engineers, and policy analysts) have important roles in autonomous vehicle development and deployment. We can help support their development and testing, and establish performance standards to legally operate on public roads. If such vehicles perform successfully and become common, they may affect planning decisions, such as the supply, design, and operation of roadways, parking, and public transit. To be prudent, such infrastructure changes should only occur after autonomous vehicle benefits, affordability, and public acceptance are fully demonstrated. This may vary—autonomous vehicles may affect some roadways and communities more than others.

A critical question is whether autonomous vehicles increase or reduce total vehicle travel and associated external costs. It could go either way. By increasing travel convenience and comfort, and allowing vehicle travel by non-drivers, total vehicle mileage could be increased. Conversely, carsharing may also be facilitated, which allows households to reduce vehicle ownership and total driving. This review suggests that they will probably increase total vehicle travel unless implemented with offsetting policies, such as efficient road and parking pricing.

Another critical issue is the degree to which potential benefits can be achieved when only a portion of vehicle travel is autonomous. Some benefits, such as improved mobility for affluent non-drivers, may occur when autonomous vehicles are uncommon and costly, but many potential benefits require that most or all vehicles on the road operate autonomously. For example, it seems unlikely that traffic densities can significantly increase, traffic lanes be narrowed, parking supply be significantly reduced, or traffic signals be eliminated until most vehicles on affected roads are capable of self-driving.

A key public policy issue is how much this technology may harm people who do not use such vehicles—for example, if traffic volumes increase, walking and cycling conditions are degraded, conventional public transit service declines, or human-driven vehicles are restricted. Some strategies, such as platooning, may require special autonomous vehicle lanes to achieve benefits. These issues will likely generate considerable debate over their merit and fairness.

Summary

The selected references and excerpts above were pulled from just a few of the research documents collected for this report (a full bibliography is provided at the end). However, several common themes emerged through these expert perspectives.

- The importance of adopting a multi-modal strategy.
- An assumption of significant parking demand reductions once AVs become common place.
- General agreement that full AV implementation (and the anticipated parking demand reductions) are 20-30 years away.
- An acknowledgment that parking structures are designed for 50-75 year lifecyles and that any parking structures being built should consider new design approaches that consider adaptive reuse.
- The importance of considering changes in the millennial generation’s travel preferences.
- The importance and impact of shared-use mobility options to provide a full range of mobility options.
- The importance of effective parking management that leverages new technologies to create improved user experiences.

Shared Mobility and "Mobility as a Service"

Information and communication technologies, combined with smartphone applications and location data from global positioning systems, are making feasible transportation services that have long been imagined but never realized on a large scale. These innovations include: carsharing, bikesharing, microtransit services, and most notably, transportation network companies (TNCs), such as Uber and Lyft.

These services are being embraced by millions of travelers who are using their smartphones to arrange for trips by car, shuttle, and public transit, as well as for short-term rental of cars and bicycles. These new services epitomize today's sharing economy and allow an increasing number of people to enjoy the mobility benefits of an automobile without owning one. They may also encourage others to leave their personal vehicle at home for the day, reduce the number of vehicles in their household, or even forgo having one at all.

The Transportation Research Board (TRB) recently released *Special Report 319: Between Public and Private Mobility: Examining the Rise of Technology-Enabled Transportation Services*. This report was developed by a special task force of transportation experts from industry and academia, and identified a range of research needs.

A copy of the report can be downloaded at: http://onlinepubs.trb.org/onlinepubs/sr/sr319.pdf

In a separate but related publication, Xerox's Innovator's *Brief for the Transportation Industry* recently presented "A Three Point Plan to Improve Urban Mobility". This brief highlights the fact that cities are going to get a lot more crowded. Today, 54% of the world's population lives in urban areas. The United Nations estimates that an additional 2.5 billion people could be based in cities by 2050. As our world becomes more urbanized, the issues of traffic congestion, parking, and access management are amplified. Xerox's brief focuses on three key points that can empower cities to be more sustainable and improve the quality of life for residents and tourists.

1. **Improve the efficiency of existing mobility infrastructure.**
   Adding more infrastructure is simply not an option in many urban environments. Using technology, we can move people, vehicles, and goods more efficiently through the existing infrastructure.
2. **Increase the capacity of the existing mobility infrastructure.**
   The goal here is to move more people, vehicles, and goods through the existing infrastructure.
3. **Change the behaviors of urban travelers.**
   This is about influencing the choices that travelers make toward options that reduce congestion. Agencies that implement dynamic pricing can reduce traffic congestion in all electronic toll collection and/or on-street parking situations, using pricing as a mechanism to influence driver choices. Smart parking programs help to increase space availability and reduce pollution by helping drivers get to a parking spot at their desired price point sooner. Incorporating telecommuting into the office culture helps to keep people and vehicles off the roads during the day. Providing accessible multimodal options such as ridesharing, car sharing, and public transportation via mobility apps creates opportunities to make different choices that can result in less personal vehicle usage and less congestion.

Both of these publications reinforce the integration of parking and mobility management strategies into a more comprehensive and connected platform of transportation choices.

The following section illustrates how far we have come in the evolution of shared mobility resources and options. The following list was created for the Silicon Valley "Mobility as a Service" project, where mobility aggregators integrated various services. It maps out the ecosystem of shared mobility options using the following major categories. For each category of shared mobility elements, examples of software or programs are provided.

- Enterprise Commute Trip Reduction (e.g., Luum, Ride Amigos)
- Mobility Aggregators (e.g., Moovit, Moovel, Urban Engines)
- Public Transit (e.g., bus, subway)
- Private Sector Transit (e.g., Bridj, Chariot, Go Carma, Via)
- Rideshare w/in 10 min (e.g., Lyft Carpool, UberPool, Ford Dynamic Social Shuttle)
- Rideshare w/in 24 hours (e.g., Carma, HOVee Carzac)
- Taxi-like services (e.g., Lyft, Uber, Juno, Sidecar)

- Carshare (e.g., Car2Go, Zipcar, Enterprise Car Share)
- P2P Carshare (e.g., Getaround, RelayRides, Ford Car Swap)
- Bikeshare (e.g., Motivate, DecoBike, Bcycle, NextBike)
- Personal Electric Transport (e.g., Enzo foldable ebike, GenZe electric bikes, Scoot (heavy scooter rental)) • Vanpooling (e.g., Enterprise, Vride)
- Commute Mode Detection Technologies (e.g., Strava, MapMyRide, Moves)
- Smartphone Transit Payment (e.g., Passport, GlobeSherpa, Masabi)
- Smartphone Parking (e.g., ParkMe, Parkmobile, Pay-by-Phone)
- Miscellaneous Apps (e.g., City Mapper, Transitscreen, Modify—TDM Trip Planner)
- Commuter Benefits (e.g., Commuter Check Direct,Commuter Benefits, Wageworks)
- Robotaxi (e.g., Uber with Robot Driver)
- Personal Rapid Transit (e.g., 2getthere, Ultra Global (London Heathrow))
- Niche Ride Match (e.g., Zimride, Otto (eRide Share))
- SOV Apps (e.g., WAZE Social Traffic, Twist for Rendezvous)
- Niche Transport (Ee.g., Boost by Benz, Shuddle, Hop/Skip/Drive)

This document illustrates the scope, variety, and evolution of this emerging industry area called "shared mobility" as parking and TDM programs merge to offer more comprehensive tapestries of access management strategies. Looking at this document from a different perspective reveals another dimension. Beyond the specific practices, there are broader categories—such as mobile communications, data aggregation, commute mode detection, personal transport, active transportation, private sector transit, and commuter benefits—that are driving the innovation of new approaches. In some cases, the intersections of these broader categories are generating synergistic applications and approaches that will have the potential to be both transformative and disruptive to our industry.

The promise and potential of these evolving products, applications, and strategies on our ability to improve access and mobility while simultaneously addressing other important issues—such as congestion mitigation, greenhouse gas emission reduction, and the promotion of a more sustainable transportation network—is exciting. Kimley-Horn believes it will be in Rochester's best interest to assess these emerging transportation options and invest in a comprehensive access management program that can improve visitor, patient and staff experiences as an integrated downtown parking and access development strategy.

Parking and Mobility Management: Monitoring and Evaluation

Creating a baseline of parking and transportation utilization and tracking the subsequent changes will be critical to planning for future parking, especially when considering the uncertain future of the transportation sector and the potential for significantly reduced parking needs (due to autonomous vehicles and other transportation usage trends).

Following are Kimley-Horn's recommendations for implementation within the first six months of operations:

1. Develop an automated system of documenting the number of campus employees by:
    a. Number of employees by tenant/institution.
    b. Number of employees by tenant/institution/by shift.

2. On an annual basis, conduct a "cordon count" in conjunction with a parking utilization survey. Cordon counts are counts taken at each campus access point or peripheral campus intersection while documenting the types of vehicles and their respective volumes. Kimley-Horn has had recent success conducting "cordon counts" using video which allows the surveyor to obtain specific numbers by type for each access point (cars/buses/bikes/peds). This data can also be useful to assess traffic conditions.

3. Define specific modal split targets as parking demand reduction strategy and provide ongoing monitoring. The graphic below shows a potential application of various parking demand reduction strategies along with their estimated parking demand reduction goals.

By clearly stating your parking demand reduction goals and mapping out the intended strategies, a logical TDM implementation and monitoring process can be created. The keys to success in this process are:

- Assign anticipated percentages to meet the overall demand reduction goals.
- Gather valid baseline data for comparative analysis.
- Develop effective performance measures related to each TDM program element.
- Implement an ongoing tracking and reporting process to measure progress.

Designing for Flexibility and Adaptive Reuse

Given the uncertain future of transportation and parking discussed in the previous chapters (particularly the potential for dramatic parking demand reductions) the question of whether a parking structure be designed today and adapted into something different tomorrow takes on a new significance. Thinking critically from an operational and design perspective, two key concepts emerge related to forward-thinking parking planning—developing strategies that promote maximum operational flexibility in short- to mid-term time frame, and designing future parking infrastructure with the capability of being adaptively reused should projections related to reduced parking demand prove to be on-target.

Planning for the Adaptive Reuse of Parking Structures

This report section explores the technical issues associated with the concept of adaptive reuse parking facilities. Designs must consider future direction of the industry, including:

- Migration of suburbanites to urban centers
- Millennials driving less and forgoing car ownership
- Car sharing services (e.g., Uber, Lyft, Zipcar)
- Connected and autonomous vehicles
- The drive towards reducing vehicular traffic and making communities becoming more pedestrian-friendly and walkable

Many communities are taking measures to meet the evolving parking and transportation needs of communities of today and of the future. For example, forward-thinking administrators are revising their zoning codes and moving away from the minimum to maximum parking ratios for selected land uses. In addition, most are recognizing reduction in parking demand for transit-oriented development (TODs) and shared-use parking.

Most people would agree that the need for parking structures is not going to go away anytime soon, even as technology is rapidly changing. Parking may not be the most glamorous element of a development or community but many community planners and developers recognize that when done right, it is the key to realizing their vision for an active and vibrant community and a successful development.

The service life of many parking structures designed is 50-75 years. As such, these facilities are and will continue to be fixtures of our urban landscape. We realize that mobility options and preferences are going to change over time as are the needs of the community. The last thing anyone wants is to build a structure that will be obsolete or severely underutilized.

What if parking structures could be designed to not only handle the current need but also be adaptable to better meet the evolving parking and transportation needs of communities in the future? What if we could future-proof the parking structure of today and design them to be adaptable to become say a community mobility hub, a community event center, or other land use types (office, clinical space, residential, etc.). Can this be done physically and economically?

We believe it can. It may also be possible for an existing structure to be retrofitted to a degree. Some would argue that it would be simpler and less costly to demolish the existing parking structure and replace it with a new, more suitable building. In some circumstances, and for many owners considering the long-term, this may not be the most environmentally responsible or cost-effective choice.

How do we go about doing this in a creative and economical way?

What should we consider and do today to allow parking structures to be multi-functional and adaptable in the future?

First, let's define the design challenge. Parking structures are unique building types with the following typical features:

- Open to the environment
- Designed to be storage facilities (Group S Occupancy), not conditioned, occupied spaces
- More horizontal than vertical in configuration

The primary focus of parking structure design has been to efficiently move cars in, store them, then move them out. In contrast, buildings for non-parking uses focus on making the occupied space safe, habitable, appealing, and accessible. There are a number of parking structure design features that don't lend themselves to a non-parking use, including:

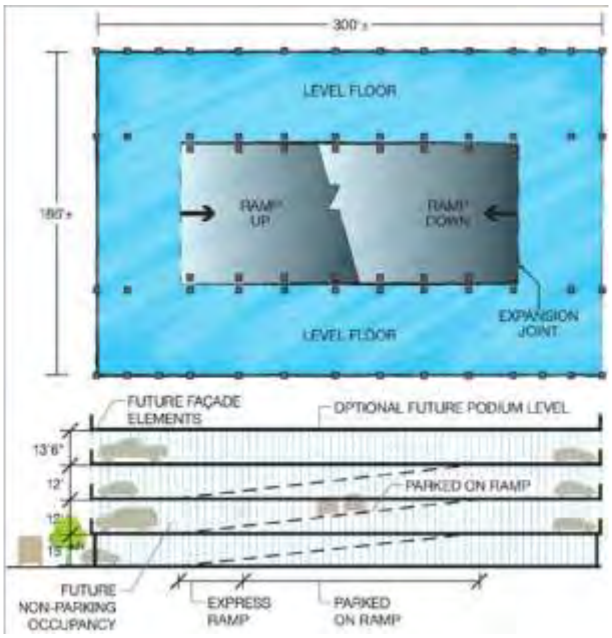
- Story (or floor-to-floor) heights. Parking structure story heights generally range between 10' 0" and 11' 6" which are not suitable for most commercial office/retail or residential use
- Sloped floors. Parking structures require sloped floors to facilitate self-parking vehicular circulation between parking levels and for drainage
- **Size, number, and layout of stairs and elevators.** Stairs are a means of egress for life safety and sized based on code prescribed occupant load factor associated with an occupancy use classification. For parking structures, the occupant load factor is 200 SF per person whereas office (Group B) and mercantile (Group M) occupancy at 100 and 60 SF person, respectively, resulting in the requirement for wider stair widths and/or additional stairs. These stairs and accompanying elevators are typically located along the perimeter of the parking structure whereas for non-parking use buildings they are typically located within the interior of the building footprint.
- **Lack of HVAC systems.** These systems are not provided for parking floor areas.
- Lack of fire protection. Many jurisdictions don't require parking structures to have fire sprinklers for fire protection whereas they are typically required for non-parking uses.
- **Lower live loading code.** The minimum code for live loading parking structures is 40 psf. For other uses such as office, retail, library reading rooms, public meeting spaces, and their corridors are between 50 and 100 psf.

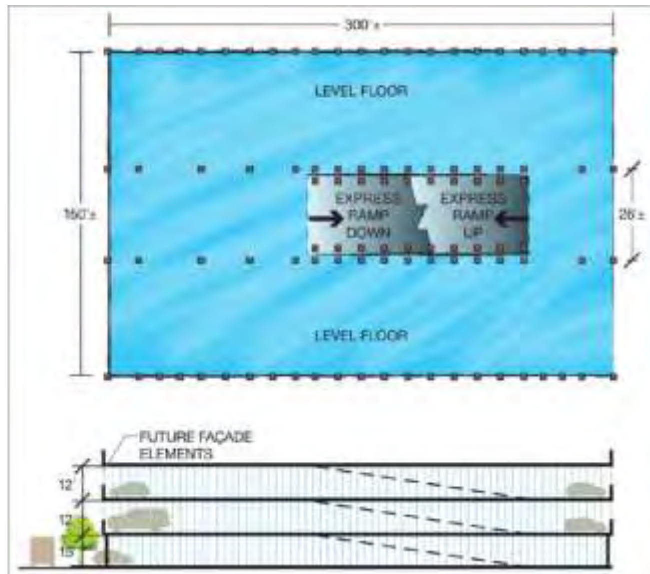
Key Parking Structure Adaptive Reuse Strategies

What can be done differently when planning for and designing parking structures of the future to compensate for these conflicting design features?

- Increase floor-to-floor heights. By increasing the first story height minimum to 15 feet and the height of typical upper stories to 12 feet, the resulting first story height can be a minimum of 15 feet and the height of typical upper stories can be 12 feet. These heights are more suitable to provide higher clear heights of 12± feet for ground level commercial/retail use and 9± feet for office, community meeting, or possibly residential use. If sufficient site length is not available to provide a parked-on ramp with these story heights or more flat floor area is desired then non-parked on express ramps (with slope > 6.67%) can be provided for a portion or the entire length of ramp. These ramps can be situated near ends of the floor plate or along its sides to provide for more flat floor area.
- Design the floor framing to allow for the ramped parking bay to be more readily demolished. One way of accomplishing this is to provide double row of columns along the bay with the ramp and expansion/construction joints at the top and bottom of each floor-to-floor ramp segment. This would likely require additional framing elements for lateral load resistance and detailing to facilitate load transfer and accommodate building movement at the expansion/construction joints. While this would also add to the initial construction costs, it would provide an opportunity for modifying each floor to be a complete flat floor plate for future uses.
- Include 25-30-feet wide light-well between parking bays to provide space for construction of additional elevator and stair cores and flat floor construction for corridors within the interior of the building footprint. Foundations for these future pedestrian circulation elements could be constructed as part of the initial construction.
- The perimeter stair and elevator cores that serve the parking structure could be located outboard to the floor plate. This will allow for easier demolition of these elements if they don't adequately serve the alternate use.
- Design floor framing for additional load carrying capacity by including provision for adding columns and beams to reduce beam and slab spans or supplement conventional and post-tensioned slab and beam reinforcement to support additional floor loads. This additional load carrying capacity could accommodate a topping slab to level out the floor drainage slope.
- Impacts of floor cross slope for drainage can be reduced by providing additional floor drains.

- Building columns, walls, and foundations could be designed to accept vertical expansion and the addition of a podium level for a public plaza recreational space or a one- or two-story light-framed (Type 5 framed wood construction) building structure.
- Design for either the removal of perimeter vehicle and pedestrian guard rails or detail connections points to accept future installation of building facade elements (e.g., curtain wall/store front system, panelized EIFS, or stucco wall system), including doors and windows to fully enclose the perimeter of the structure.
- Provide additional capacity in the electrical service, sanitary sewer, and fire protection systems. Include provisions for electrical and mechanical chases to accommodate duct work and cabling, and additional space for mechanical and electrical service and fire protection equipment (e.g., fire pumps and emergency generators).





Additional structural and architectural consideration may need to be identified based on the whether the parking structure is cast-in-place concrete, precast concrete, or steel framed construction.

We recognize that not all projects will lend themselves for implementing design enhancement for facilitating future adaptive reuse but for some projects and owners, it may be beneficial to investigate the possibilities during project planning and design development. Parking structures designed to accommodate future conversion to a different use will cost more initially. The economic decision to proceed will need to be considered by community and institutional leaders and owners to determine the feasibility of such an investment.

Advancing the Concept of Parking Structure Adaptive Reuse

Given the potential of this concept and its specific relevance to the new Druid Hills healthcare campus we have attempted to advance this concept further by exploring the following key areas below:

- Preliminary Building Code Review (comparative analyses of different uses and occupancy classifications)
- The Development of Prototype Design Concepts
- Estimates of Probable Cost for Prototype Concept Designs

Preliminary Code Review

We conducted a preliminary code review of the 2012 International Building Code (2012 IBC) for the near term and potential building uses to identify the basic requirements that need to be addressed in our design concepts. Each building or portion of a building is assigned a single occupancy classification based on its intended use. Occupancy classifications reviewed include parking structure use (Group S occupancy), professional office use (Group B occupancy), mercantile use (Group M occupancy), and residential use (Group R occupancy). Tables 1, 2, and 3 present results of this code review.

TABLE 1—Preliminary Code Review
Comparison of Group S and Group M Occupancy Requirements

2012 IBC Code Section	Parking Structure Use: Group S-2 Occupancy	Retail Use: Group M Occupancy
Chap 4 – 406.4.1 Chap 12 – 1208.2	Minimum clear height is 7’-0”	Minimum ceiling height in habitable spaces and corridors is 7’-6”
Chap 4 – 406.4.3	Vehicle barriers minimum 2’-9” in height	
Chap 4 – 406.5 Chap 5 – 705.8	Openings for natural ventilation purposes: Uniformly distributed openings on two or more exterior sides. The area of such openings in exterior walls on a tier must be at least 20% of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall constitute a minimum of 40% of the perimeter of the tier.	Maximum allowable area of unprotected and protected opening is a function of the fire separation distance from property line. Refer to Table 705.8
Chap 5 – 508; 510 Chap 6 – 601; 602	Noncombustible Type 1 or Type 2	Noncombustible Type 1 or Type 2
Chap 4 – 406.5.5 Chap 5 – 503; 504.2; 506; 508.4	Maximum height allowable; area per tier; and maximum number of stories Type 1A – unlimited; unlimited; unlimited Type 1B – 160 feet; unlimited; 12 stories Type 2A – 85 feet; 78,000 SF; 6 stories Type 2B – 75 feet; 52,000 SF; 4 stories	Maximum height allowable; area per tier; and maximum number of stories Type 1A – unlimited; unlimited; unlimited Type 1B – 160 feet; unlimited; 12 stories Type 2A – 85 feet; 43,000 SF; 5 stories Type 2B – 75 feet; 25,000 SF; 3 stories
Chap 5 – 508.4, 510	Horizontal separation with assembly having fire-resistance rating of not less than 3 hours between separated occupancies	Horizontal separation with assembly having fire-resistance rating of not less than 3 hours between separated occupancies

Chap 7 – 706.4; 707; 708	Fire wall resistance rating – 2 hours Fire barrier assemblies – 2 hours Fire partition walls – 1 hour	Fire wall resistance rating – 3 hours Fire barrier assemblies – 2 hours Fire partition walls – 1 hour
Chap 9 – 903	Generally, not required in tiers classified as open for natural ventilation in mixed-use S-2 open parking structures unless required by local jurisdiction.	Required where one of the following conditions exists: Fire area > 12,000 SF fire area 3+ stories above-grade Total fire areas (all floors) > 24,000 SF Furniture/mattress sale area > 5,000 SF
Chap 9 – 905	Class I standpipes allowed with automatic sprinkler system	Class I standpipes allowed with automatic sprinkler system
Chap 9 – 907	Fire alarms and detection systems – not required	Manual fire alarm system required where one of the following conditions exists: Combined occupant load ≥ 500 Occupant load > 100 above or below the lowest level of exit discharge *Exception: When an automatic sprinkler system is installed and* occupant notification appliances activate upon sprinkler use.
Chap 10 – 1004	Occupant load = 200 SF gross per occupant	Occupant load = 60 SF gross per occupant. Basement and grade floor areas = 30 SF gross per occupant. Storage, stock, shipping areas = 300 SF per occupant
Chap 10 – 1005	Stair egress width [in.] = 0.2*occupant load (with automatic sprinkler system)	Stair egress width [in.] = 0.2*occupant load (with automatic sprinkler system)
Chap 10 – 1007	Area of refuge not required in stairways in open parking structures	Area of refuge not required at stairways in building with automatic sprinkler system
Chap 10 – 1016	Maximum travel distance to egress stair with sprinkler system = 400 feet	Maximum travel distance to egress stair with sprinkler system = 250 feet
Chap 16 – 1604	Risk Category II	Risk Category II
Chap 16 – 1607	Live load = 40 psf	Live load first/ground floor = 100 psf Live load upper floors = 75 psf
Chap 29 – 2902	Plumbing fixtures not required	Minimum # of plumbing fixtures: Water Closets: 1 per 500 occupants Lavatories: 1 per 750 occupants Drinking fountains: 1 per 1,000 occupants

TABLE 2—Preliminary Code Review Comparison of Group S and Group B Occupancy Requirements		
2012 IBC Code Section	**Parking Structure Use: Group S-2 Occupancy**	Professional Office Use: Group B Occupancy
Chap 4 – 406.4.1 Chap 12 – 1208.2	Minimum clear height is 7'-0"	Minimum ceiling height in habitable spaces and corridors is 7'-6"
Chap 4 – 406.4.3	Vehicle barriers minimum 2'-9" in height	
Chap 4 – 406.5 Chap 5 – 705.8	Openings for natural ventilation purposes: Uniformly distributed openings on two or more exterior sides. The area of such openings in exterior walls on a tier must be at least 20 % of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall constitute a minimum of 40 % of the perimeter of the tier.	Maximum allowable area of unprotected and protected opening is a function of the fire separation distance from property line. Refer to Table 705.8
Chap 5 – 508; 510 Chap 6 – 601; 602	Noncombustible Type 1 or Type 2	Noncombustible Type 1 or Type 2
Chap 4 – 406.5.5 Chap 5 – 503; 504.2; 506; 508.4	Maximum Height; Allowable area per tier; and maximum number of stories Type 1A – unlimited; unlimited; unlimited Type 1B – 160 feet; unlimited; 12 stories Type 2A – 85 feet; 78,000 SF; 6 stories Type 2B – 75 feet; 52,000 SF; 4 stories	Maximum Height; Allowable area per tier; and maximum number of stories Type 1A – unlimited; unlimited; unlimited Type 1B – 160 feet; unlimited; 12 stories Type 2A – 85 feet; 75,000 SF; 6 stories Type 2B – 75 feet; 46,000 SF; 4 stories
Chap 5 – 508.4, 510	Horizontal separation with assembly having fire-resistance rating of not less than 3 hours between separated occupancies.	Horizontal separation with assembly having fire-resistance rating of not less than 3 hours between separated occupancies
Chap 7 – 706.4; 707; 708	Fire wall resistance rating - 2hours Fire barrier assemblies – 2 hours Fire partition walls – 1 hour	Fire wall resistance rating – 3 hours Fire barrier assemblies – 2 hours Fire partition walls – 1 hour
Chap 9 – 903	Generally, not required in tiers classified as open for natural ventilation in mixed-use, S-2 open parking structures unless required by local jurisdiction.	Required when building height is greater than or equal to 55 feet
Chap 9 – 905	Class I standpipes allowed with automatic sprinkler system	Class I standpipes allowed with automatic sprinkler system
Chap 9 – 907	Fire alarms and detection systems – not required	Manual fire alarm system required where one of the following conditions exists: Combined occupant load ≥ 500 Occupant load > 100 above or below the lowest level of exit discharge *Exception: When an automatic sprinkler system is installed and* occupant notification appliances activate upon sprinkler use

Chap 10 – 1004	Occupant load = 200 SF gross per occupant	Occupant load = 100 SF gross per occupant
Chap 10 – 1005	Stair egress width [in.] = 0.2*occupant load (with automatic sprinkler system)	Stair egress width [in.] = 0.2*occupant load (with automatic sprinkler system)
Chap 10 – 1007	Area of refuge not required in stairways in open parking structures	Area of refuge not required at stairways in building with automatic sprinkler system
Chap 10 – 1016	Maximum travel distance to egress stair with sprinkler system = 400 feet	Maximum travel distance to egress stair with sprinkler system = 300 feet
Chap 16 – 1604	Risk Category II	Risk Category II
Chap 16 – 1607	Live load = 40 psf	Live load upper floors = 50 psf Live load for corridors above first floor = 80 psf Live load for lobbies and first-floor/ground floor corridors = 100 psf
Chap 29 – 2902	Plumbing fixtures not required	Minimum # of plumbing fixtures: Water closets: 1 per 25 for the first 50 occupants and 1 per 50 for the remainder exceeding 50 occupants Lavatories: 1 per 40 for the first 80 occupants and 1 per 80 for the remainder exceeding 80 occupants Drinking fountains: 1 per 100 occupants

TABLE 3—Preliminary Code Review Comparison of Group S and Group R Occupancy Requirements		
2012 IBC Code Section	**Parking Structure Use: Group S-2 Occupancy**	**Multifamily Residential Use: Group R-2 Occupancy**
Chap 4 – 406.4.1 Chap 12 – 1208.2	Minimum clear height is 7'-0"	Minimum ceiling height in habitable spaces and corridors is 7'-6"
Chap 4 – 406.4.1 Chap 12 – 1208.2	Minimum clear height is 7'-0"	Minimum ceiling height in habitable spaces and corridors is 7'-6"
Chap 4 – 406.4.3	Vehicle barriers minimum 2'-9" in height	
Chap 4 – 406.5 Chap 5 – 705.8	Openings for natural ventilation purposes: Uniformly distributed openings on two or more exterior sides. The area of such openings in exterior walls on a tier must be at least 20 % of the total perimeter wall area of each tier. The aggregate length of the openings considered to be providing natural ventilation shall constitute a minimum of 40 % of the perimeter of the tier.	Maximum allowable area of unprotected and protected opening is a function of the fire separation distance from property line. Refer to Table 705.8
Chap 5 – 508; 510 Chap 6 – 601; 602	Noncombustible Type 1 or Type 2	Noncombustible Type 1 or Type 2
Chap 4 – 406.5.5 Chap 5 – 503; 504.2; 506; 508.4	Maximum height; allowable area per tier; and maximum number of stories Type 1A – unlimited; unlimited; unlimited Type 1B – 160 feet; unlimited; 12 stories Type 2A – 85 feet; 78,000 SF; 6 stories Type 2B – 75 feet; 52,000 SF; 4 stories	Maximum height; allowable area per tier; and maximum number of stories Type 1A – unlimited; unlimited; unlimited Type 1B – 160 feet; unlimited; 12 stories Type 2A – 60 feet; 75,000 SF; 4 stories Type 2B – 60 feet; 46,000 SF; 4 stories
Chap 5 – 508.4, 510	Horizontal separation with assembly having fire-resistance rating of not less than 3 hours between separated occupancies	Horizontal separation with assembly having fire-resistance rating of not less than 3 hours between separated occupancies
Chap 7 – 706.4; 707; 708	Fire wall resistance rating – 2 hours Fire barrier assemblies – 2 hours Fire partition walls – 1 hour	Fire wall resistance rating – 3 hours Fire barrier assemblies – 2 hours Fire partition walls – 1 hour
Chap 9 – 903	Generally, not required in tiers classified as open for natural ventilation in mixed-use S-2 open parking structures unless required by local jurisdiction.	Required
Chap 9 – 905	Class I standpipes allowed with automatic sprinkler system.	Class I standpipes allowed with automatic sprinkler system.

Chap 9 – 907	Fire alarms and detection systems – not required	Manual fire alarm system required where one of the following conditions exists: Dwelling/sleeping unit is located 3+ stories above lowest level of discharge Building contains 16+ dwelling units *Exception: When an automatic sprinkler system is installed and* occupant notification appliances activate upon sprinkler use
Chap 10 – 1004	Occupant load = 200 SF gross per occupant	Occupant load = 100 SF gross per occupant
Chap 10 – 1005	Stair egress width [in.] = 0.2*occupant load (with automatic sprinkler system)	Stair egress width [in.] = 0.2*occupant load (with automatic sprinkler system)
Chap 10 – 1007	Area of refuge not required in stairways in open parking structures	Area of refuge not required at stairways in building with automatic sprinkler system
Chap 10 – 1016	Maximum travel distance to egress stair with sprinkler system = 400 feet	Maximum travel distance to egress stair with sprinkler system = 300 feet
Chap 16 – 1604	Risk Category II	Risk Category II
Chap 16 – 1607	Live load = 40 psf	Live load = 40 psf Live load for public rooms and corridors serving dwelling units = 100 psf
Chap 29 – 2902	Plumbing fixtures not required	Minimum # of plumbing fixtures: Water closets: 1 per dwelling unit Lavatories: 1 per dwelling unit Bathtubs or showers: I per dwelling unit Kitchen sink: 1 per dwelling unit Automatic clothes water connection: 1 per 20 dwelling units

Prototype Design Concepts

Concepts presented in this section have been developed under the assumption that in the near-term, this building will be a mixed-use parking structure with retail/commercial space at the street level and parking at all above-grade supported levels. In the future, portions of the building's above-grade levels would be converted to either general office or residential apartment use with the remainder of floor area used for parking.

These design concepts are not intended to address all design aspects related to future-proofing the parking structure but rather an attempt to address some key aspects to providing an adaptable parking structure. These concepts should only be considered as examples of what is possible. Additional structural, architectural, and MEP design consideration may need to be identified and addressed during design development of these concepts.

Concept 1

Concept 1 is depicted in Sheet 1A (near-term mixed-uses) and Sheet 1B (future mixed-uses) of the enclosed drawing exhibits. Key attributes of Concept 1 are summarized as follows:

CONCEPT 1A (NEAR-TERM MIXED-USES)

- Four-story building with footprint of 302 feet x 153 feet
- Total building floor area of approximately 223,260 SF which includes approximately 15,000 gross SF of ground level general retail space with a depth of approximately 60 feet
- First-story height of 15 feet and typical above-grade story height of 12 feet, building height to top of parapet of approximately 55 feet
- Single parking bay on ground level and two bays of parking on each of the above-grade levels providing approximately 431, 8.5 feet x 18 feet, 90-degree stalls. Note that this total does not account for loss of spaces due to ADA accommodations, motorcycle and bicycle parking, and utility and storage rooms.
- Single thread, non-parked on, express ramp provided along back side of building for vehicle circulation between parking levels. A single thread helix is a ramp orientation that circulates vertically one floor with each 360 degrees of revolution. This ramp has a double row of columns along its interior to allow for the ramped parking bay to be more readily demolished if it is not desired to include parking in the future mixed-use building scenario.
- Building footprint includes a 44 feet x 28 feet interior lightwell between parking bays to provide space for construction of an additional elevator and stair core, and flat floor construction for corridors within the interior of the office/residential use footprint.
- Average design parking efficiency provided is 483 SF per stall. This parking efficiency is considered poor relative to what can typically be provided (360-380 SF/per stall) with short span construction and parked on ramps. This poor parking efficiency is primarily attributed to having a non-parked on express ramp and lightwell.
- Building construction consists of conventionally reinforced (not post-tensioned) 10-inch thick cast-in-place concrete two-way flat slab with drop panels supported by reinforced concrete columns on shallow spread and wall footings. Floor framing, columns and footings are designed for increased live and dead floor loads associated with future office/ residential use on above-grade levels. Post-tensioned floor construction was not considered to allow for flexibility in the future for making penetrations to facilitate routing of MEP conduits and piping.
- Lateral loads are resisted by moment frames.
- The foundations are designed to support additional live and dead loads associated with future conversion of above-grade levels to office/residential uses.
- Catchment area per floor drain would be approximately 3,600 SF with drains located along Gridline 5. Spot floor elevation at drain locations would be on the order 8-10 inches below the floor elevation along floor exterior perimeter. This results in providing a minimum drainage cross slope of 1%.

Concept 1B (Future mix of uses)

Modifications to the near-term mixed-use concept:

- Total of approximately 48,600 gross SF of office/residential use within the upper three stories of building. The depth of office/residential space is approximately 60 feet.
- Single parking bay on ground level and the three above-grade levels and two parking bays on the top level providing approximately 293, 8.5 feet x 18 feet, 90-degree stalls. Note that this total does not account for loss of spaces due to ADA accommodations, motorcycle and bicycle parking, and utility and storage rooms. Average design parking efficiency provided is 525 SF per stall.
- An interior elevator and stair core constructed within the lightwell area providing two elevators and one stair.
- Removal of floor drains and addition of 2- to 4-inch thick lightweight concrete topping to level out the floor drainage slope on elevated levels.
- Addition of a 3-hour fire rated wall assembly along Gridline 5 to separate the parking use from the office/residential use.

- Construction of facade elements (e.g. curtain wall/store front system, panelized rainscreen, stucco wall system, etc.), including windows to fully enclose the exterior perimeter of the office/residential use floor area.
- HVAC and plumbing fixtures (water closets, lavatories, etc.) to condition and service the occupied office/residential uses.

Concept 2

Concept 2 is depicted in Sheet 2A (near-term mixed-uses) and Sheet 2B (future mixed-uses) of the enclosed drawing exhibits. Key attributes of Concept 2 as depicted are summarized as follows:

CONCEPT 2A (NEAR-TERM MIXED-USES)

- Four-story building with footprint of approximately 290 feet x 182 feet.
- Total building floor area of 254,700 SF which includes approximately 17,560 gross SF of ground level general retail space with a depth of approximately 60 feet.
- First-story height of 15 feet, typical above-grade story height of 12 feet, building height to top of parapet of 55 feet.
- Grade plus four supported levels with two bays of parking on ground level and three bays of parking on the four supported levels providing approximately 494, 8.5 feet x 18 feet, 90-degree stalls. Note that this total does not account for loss of spaces due to ADA accommodations, motorcycle and bicycle parking, and utility and storage rooms.
- Single thread, non-parked on, express ramp in switch back configuration provided along the side of building for vehicle circulation between parking levels. This ramp has a double row of columns along its interior to allow for the ramped parking bay to be more readily demolished if it is not desired to include parking in the future mixed-use building scenario.
- Building footprint includes a 28 feet x 28 feet interior lightwell between parking bays to provide space for construction of additional elevator and stair core and flat floor construction for corridors within the interior of the office/residential use footprint.
- Average design parking efficiency provided is 480 SF per stall. This parking efficiency is considered poor relative to what can typically be provided (360-380 SF/per stall) with short span construction and parked on ramps. This poor parking efficiency can primarily be attributed to having a non-parked on express ramp and a lightwell.
- Building construction consists of conventionally reinforced (not post-tensioned) 10-inch thick, cast-in-place concrete two-way flat slab with drop panels supported by reinforced concrete columns on shallow spread and wall footings. Floor framing, columns, and footings are designed for increased live and dead floor loads associated with future office/ residential use on above-grade levels. Post-tensioned floor construction was not considered to allow for flexibility in the future for making penetration to facilitate routing of MEP conduits and piping.
- Lateral loads are resisted by moment frames.
- The foundations are designed to support additional live and dead loads associated with future conversion of above-grade levels to office/residential uses.
- Catchment area of 2,700 and 3,600 SF per floor drain with drains located between Gridlines 3 and 4, and 5 and 6. Spot floor elevation at drain locations would be on the order 8- to 10-inches below the floor elevation along floor exterior perimeter. This results in providing a minimum drainage cross slope of 1%.

Concept 2B (Future mix of uses)

Modifications to the near-term mixed-use concept:

- Total of approximately 65,600 gross SF of office/residential use on the upper three stories of building. The depth of office/ residential space is approximately 120 feet.
- Two parking bays on ground level, one and one-half parking bays on three supported levels, and three parking bays on the top level provide approximately 302, 8.5 feet x 18 feet, 90-degree stalls. Note that this total does not account for loss of spaces due to ADA accommodations, motorcycle and bicycle parking, and utility and storage rooms. Average design parking efficiency provided is 560 SF per stall.
- An interior elevator and stair core constructed within the lightwell area providing two elevators and one stair.
- Removal of floor drains and addition of 2- to 4-inch thick lightweight concrete topping to level out the floor drainage slope on elevated levels.

- Addition of a 3-hour fire rated wall assembly to separate the parking use from the office/residential use.
- Construction of facade elements (e.g. curtain wall/store front system, panelized rainscreen, stucco wall system, etc.), including windows to fully enclose the exterior perimeter of the office/residential use floor area.
- HVAC and plumbing fixtures (water closets, lavatories, etc.) to condition and service the occupied office/residential uses.

Opinion of Probable Cost for Prototype Concept Designs

- Conceptual level opinions of probable cost were developed for each near-term and future mixed-use parking structure concept. The opinions of probable project costs are presented for comparative purposes in 2017 dollars for the Rochester, MN market. These costs do not include items such as land acquisition, project financing and site environmental evaluations, and owner soft costs such as site geotechnical investigations and recommendations and owner's administrative and legal costs. Escalation percentage should be established by the owner based on their assumptions as to the anticipated year of project bidding and construction.
- **Tables 4 and 5** provide an opinion of probable cost for a typical stand-alone, 4-story above-grade parking structure with long-span post-tensioned construction, 10 feet story heights, and typical facade treatments and features comparable in size to the Concept 1 and Concept 2.

TABLE 4—Typical Standalone 4-Story Above-grade Parking Structure Concept 1

Item	Square Footage	Unit Price ($/SF)	Extension
Standalone Parking Structure	223,260	$50.00	$11,163,000
Construction Contingency (10%)			$1,116,300
Design Contingency (20%)			$2,232,600
Total	**223,600**	**$65.00**	**$14,511,900**

TABLE 5—Typical Stand-alone 4-Story Above-grade Parking Structure Concept 2

Item	Square Footage	Unit Price ($/SF)	Extension
Standalone Parking Structure	254,700	$50.00	$12,735,000
Construction Contingency (10%)			$1,273,500
Design Contingency (20%)			$2,547,000
Total	**254,700**	**$65.00**	**$16,555,500**

Table 6 through 9 provide an opinion of probable cost for Concept 1 and Concept 2 for the near-term mixed-use and future mixed-uses concept scenarios.

TABLE 6—Concept 1A (Near-term Mixed-use) Opinion of Probable Cost			
Item	**Square Footage**	**Unit Price ($/SF)**	**Extension**
Parking Structure	208,260	$70.50	$14,682,000
Ground Level Retail Space Buildout	15,000	$65.50	$982,500
Subtotal	223,260	$70.16	$15,664,500
Construction Contingency (10%)			$1,566,450
Design Contingency (20%)			$3,132,900
Total	**223,260**	**$91.20**	**$20,363,850**

TABLE 7—Concept 1B (Future Mixed-uses) Opinion of Probable Costs			
Item	**Square Footage**	**Unit Price ($/SF)**	**Extension**
Parking Structure	208,260	$70.50	$14,682,000
Ground Level Retail	15,000	$65.50	$982,500
Build out Office/Residential Space	48,600	$104.00	$5,054,000
Subtotal	223,260	$92.80	$20,718,500
Construction Contingency (10%)			$2,071,850
Design Contingency (20%)			$4,143,700
Total	**223,260**	**$120.60**	**$26,934,050**

TABLE 8—Concept 2A (Near-term Mixed-use) Opinion of Probable Cost			
Item	**Square Footage**	**Unit Price ($/SF)**	**Extension**
Parking Structure	237,144	$70.00	$16,600,000
Ground Level Retail Space Buildout	17,560	$67.00	$1,176,500
Subtotal	254,700	$69.80	$17,776,500
Construction Contingency (10%)			$1,777,650
Design Contingency (20%)			$3,555,300
Total	**254,700**	**$90.70**	**$23,109,450**

TABLE 9—Concept 2B (Future Mixed-uses) Opinion of Probable Cost			
Item	**Square Footage**	**Unit Price ($/SF)**	**Extension**
Parking Structure	237,144	$70.00	$16,600,000
Ground Level Retail	17,560	$67.00	$1,176,500
Build out Office/Residential Space	65,560	$103.00	$6,753,000
Subtotal	254,700	$96.30	$24,529,500
Construction Contingency (10%)			$2,452,950
Design Contingency (20%)			$4,905,900
Total	**254,700**	**$125.20**	**$31,888,350**

Opinions rendered as to costs, including but not limited to, opinions as to the costs of construction and materials, are made based on RS Means square foot unit pricing and our experience, and represent our judgment as an experienced and qualified professional firm that is familiar with the industry. No solicitation or information from contractors was gathered.

Phased Parking Development Options

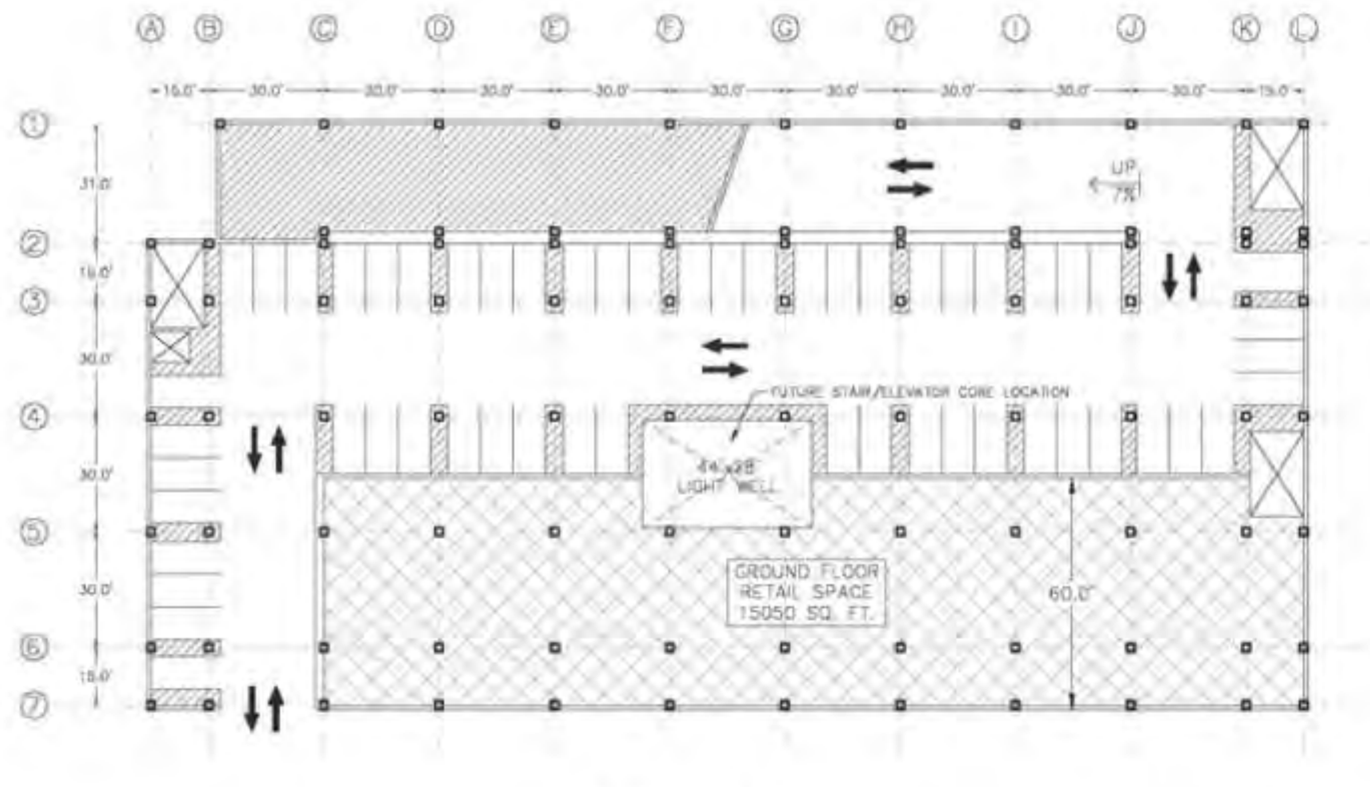
Based on the projected timeline related to the potential disruption of the current parking and transportation paradigm (e.g., autonomous vehicles, *see Chapter 4.0*), we do not anticipate a major reduction in parking demand within the Phase One development period. As such, we are recommending a phased approach to parking infrastructure development. As any new parking structure will have a design life of 50-75 years, adopting some of the strategies listed in the previous chapter could provide value even in Phase One parking development.

For parking infrastructure in the initial phases, we also recommend that these structures be designed to exceed minimum standards for ease of use. We also recommend incorporating a range of parking management best practices that will allow higher levels of service, especially for visitor and patient parking areas. This would include amenities such as:

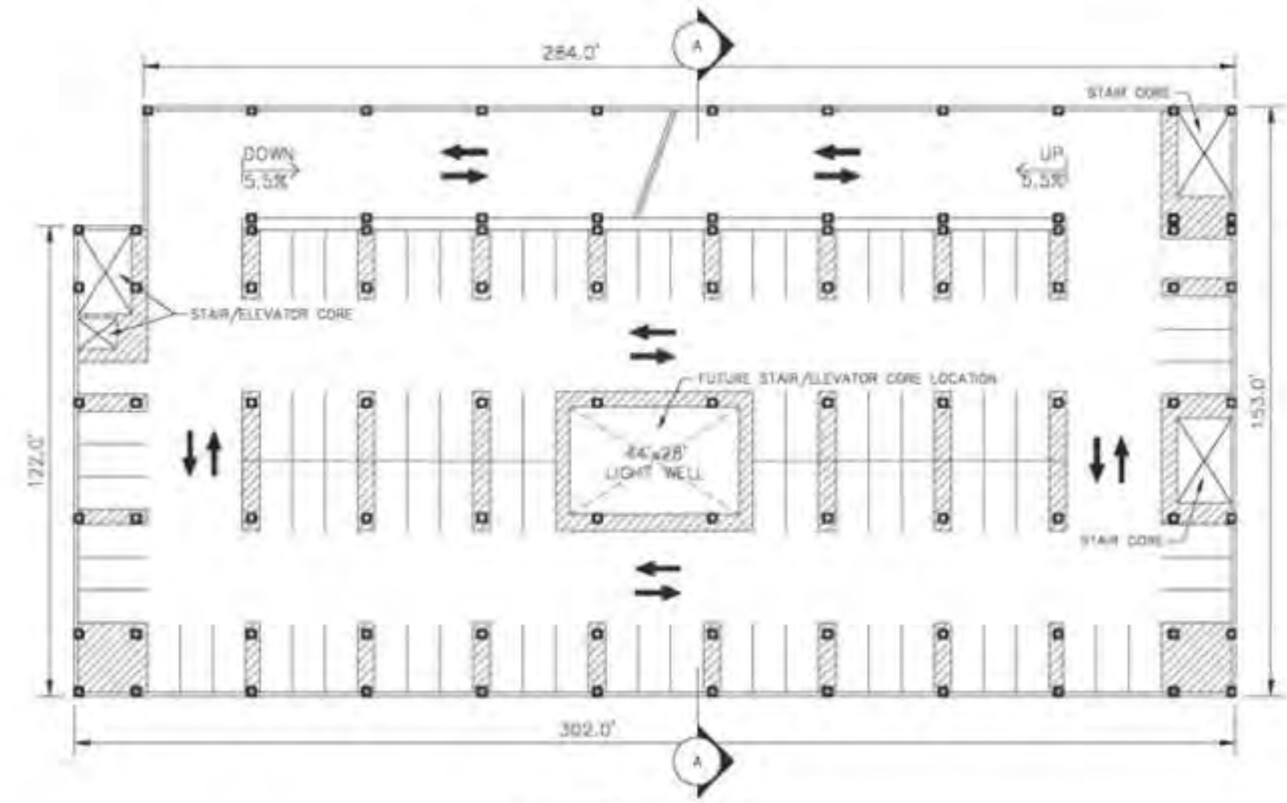
- Higher floor-to-floor heights
- White interiors
- Lighting levels that exceed IES minimums
- Glass-backed elevators
- Enhanced graphics/level theming and wayfinding

For future parking infrastructure (beyond the initial Phase of development), we recommend that Children's develop an aggressive parking and modal split monitoring program designed to track parking demand (as well as progress on the evolution and impacts of autonomous vehicle and shared mobility). Depending on these results, the design of any additional parking structures should strongly consider parking design options that will allow future adaptive reuse (see the previous chapter for details).

CONCEPT 1: NEAR-TERM USES



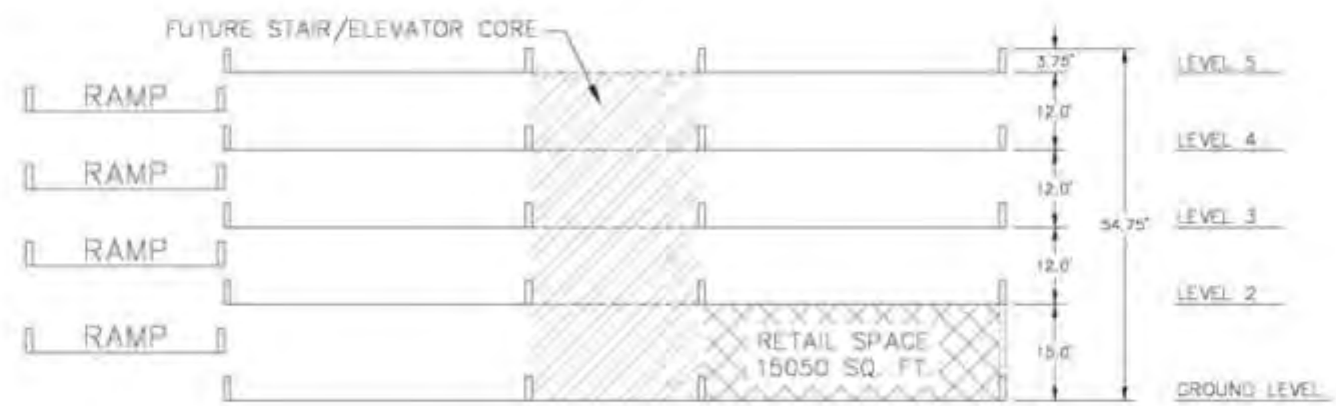
GROUND LEVEL



TYPICAL LEVEL

PARKING STALL COUNT SUMMARY				
LEVEL	SPACES (8.5'x18')	AREA (SF)	PARKING EFFICIENCY	RETAIL AREA (SF)
GROUND LEVEL	55	25615	466	15050
LEVEL 2	94	45648	486	–
LEVEL 3	94	45648	486	–
LEVEL 4	94	45648	486	–
LEVEL 5	94	45648	486	–
TOTAL	431 *	208207	483	15050

* THE TOTAL NUMBER OF SPACES HAS NOT BEEN REDUCED TO ACCOUNT FOR LOSS OF SPACES DUE TO ADA ACCOMMODATION, MOTORCYCLE PARKING, AND UTILITY AND STORAGE ROOMS.



SECTION A–A

SHEET 1A

Kimley»Horn

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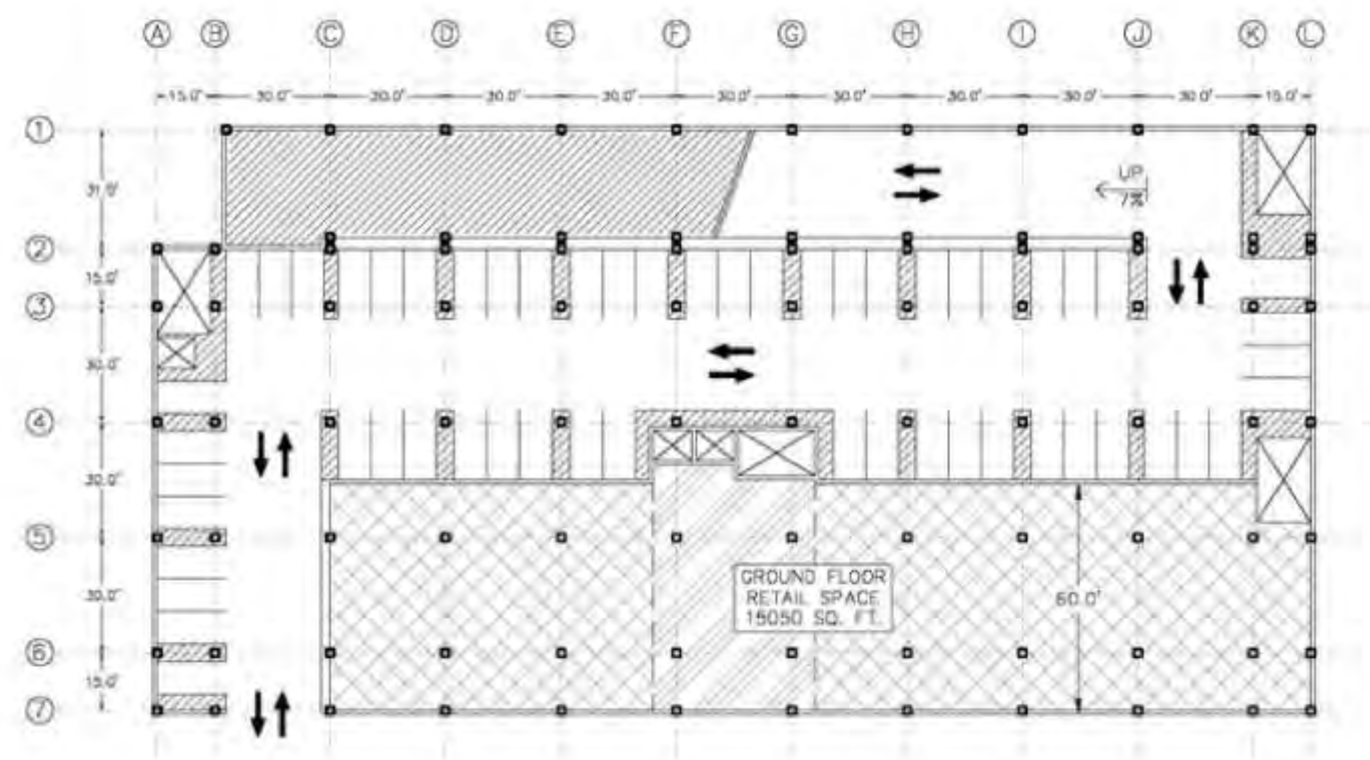
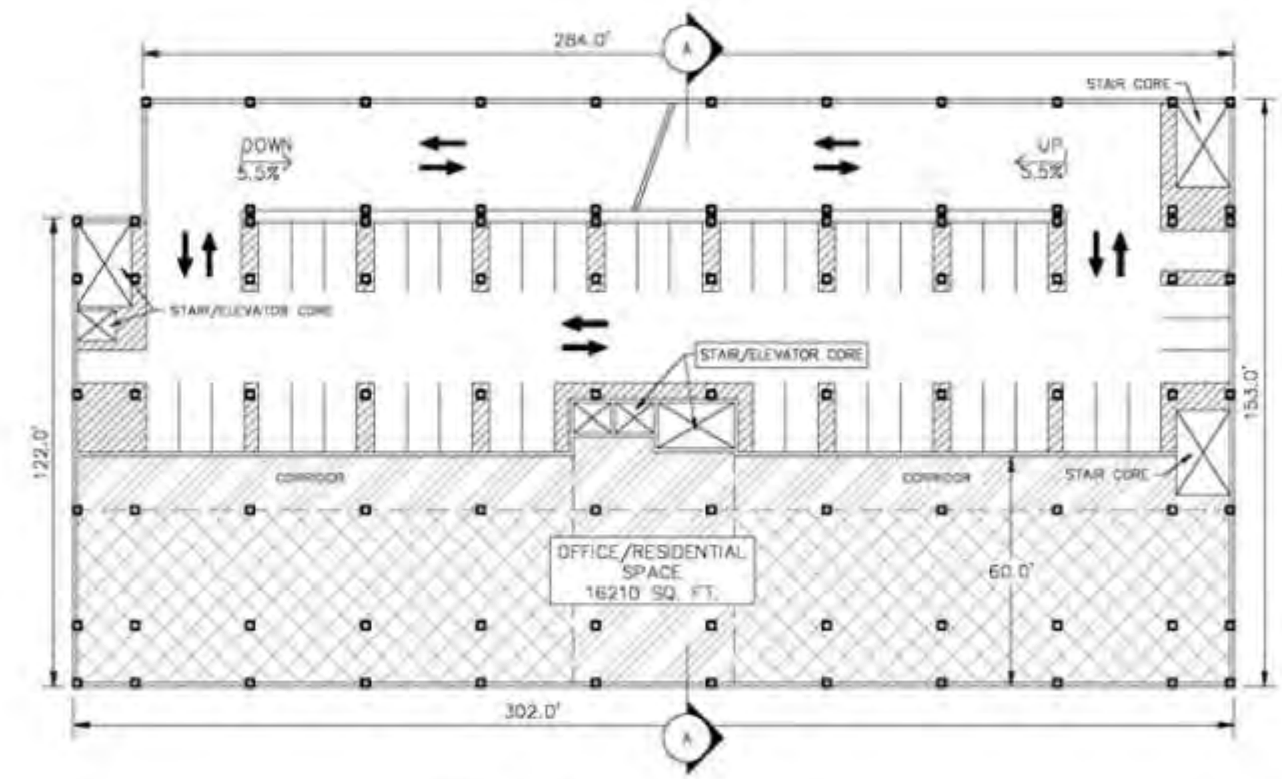
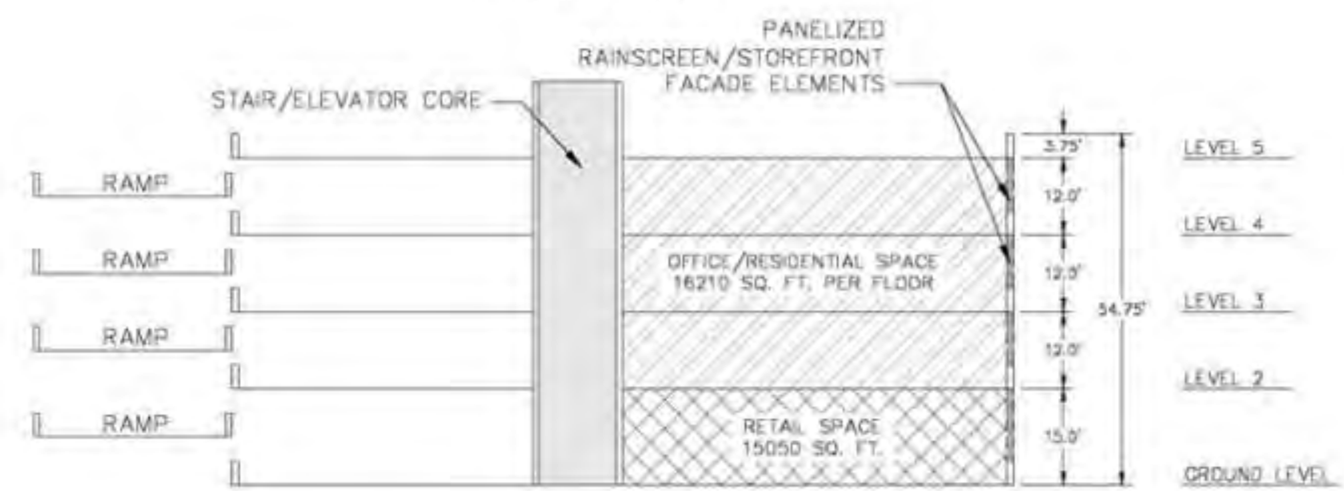
CONCEPT 1: FUTURE BUILDING USES



GROUND LEVEL



TYPICAL LEVEL



SECTION A–A

PARKING STALL COUNT SUMMARY					
LEVEL	SPACES (8.5'x18')	AREA (SF)	PARKING EFFICIENCY	RETAIL AREA (SF)	OFFICE/RESIDENTIAL AREA (SF)
GROUND LEVEL	55	25615	466	15050	—
LEVEL 2	48	27530	574	–	16210
LEVEL 3	48	27530	574	–	16210
LEVEL 4	48	27530	574	–	16210
LEVEL 5	94	45648	486	–	—
TOTAL	293 *	153853	525	15050	48530

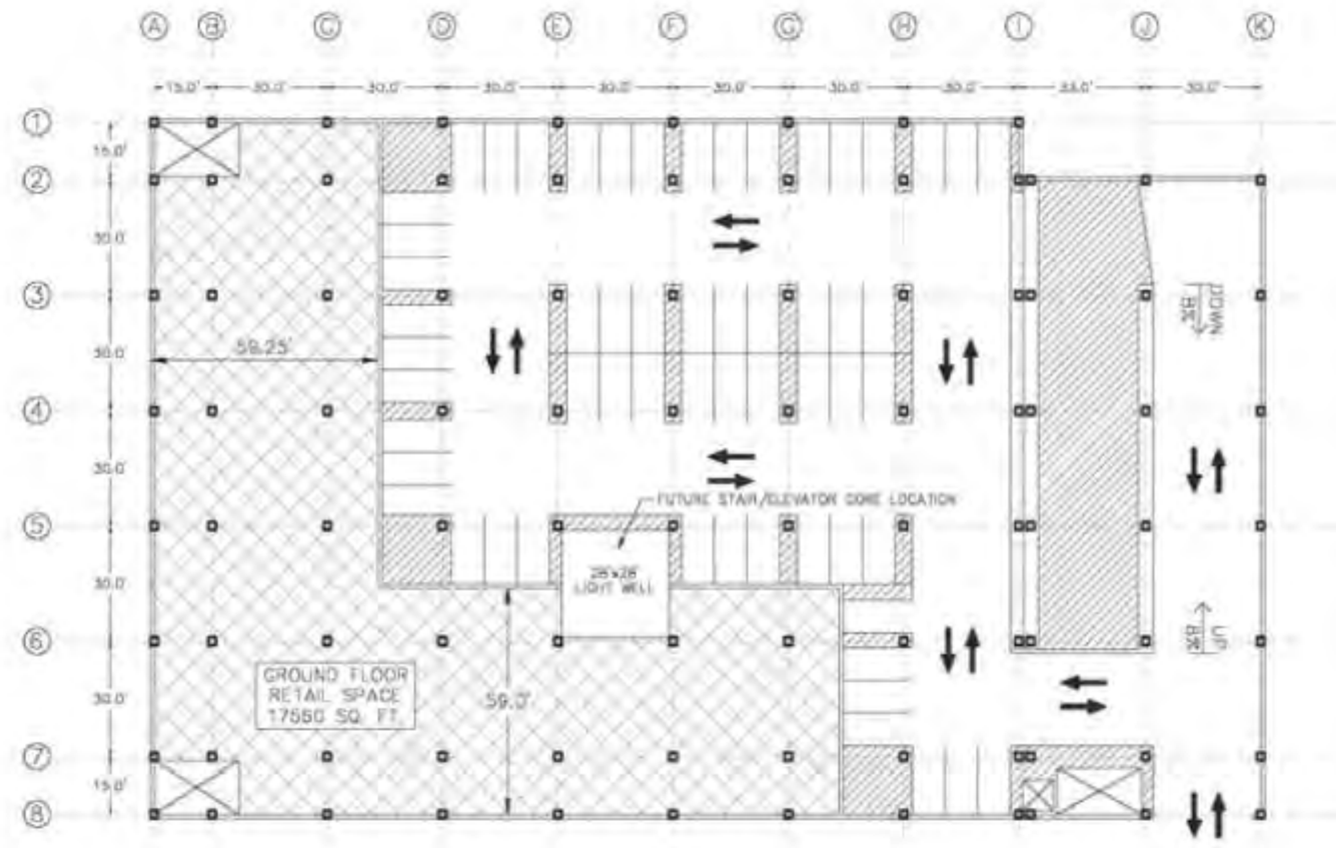
* THE TOTAL NUMBER OF SPACES HAS NOT BEEN REDUCED TO ACCOUNT FOR LOSS OF SPACES DUE TO ADA ACCOMMODATION, MOTORCYCLE PARKING, AND UTILITY AND STORAGE ROOMS.

SHEET 1B

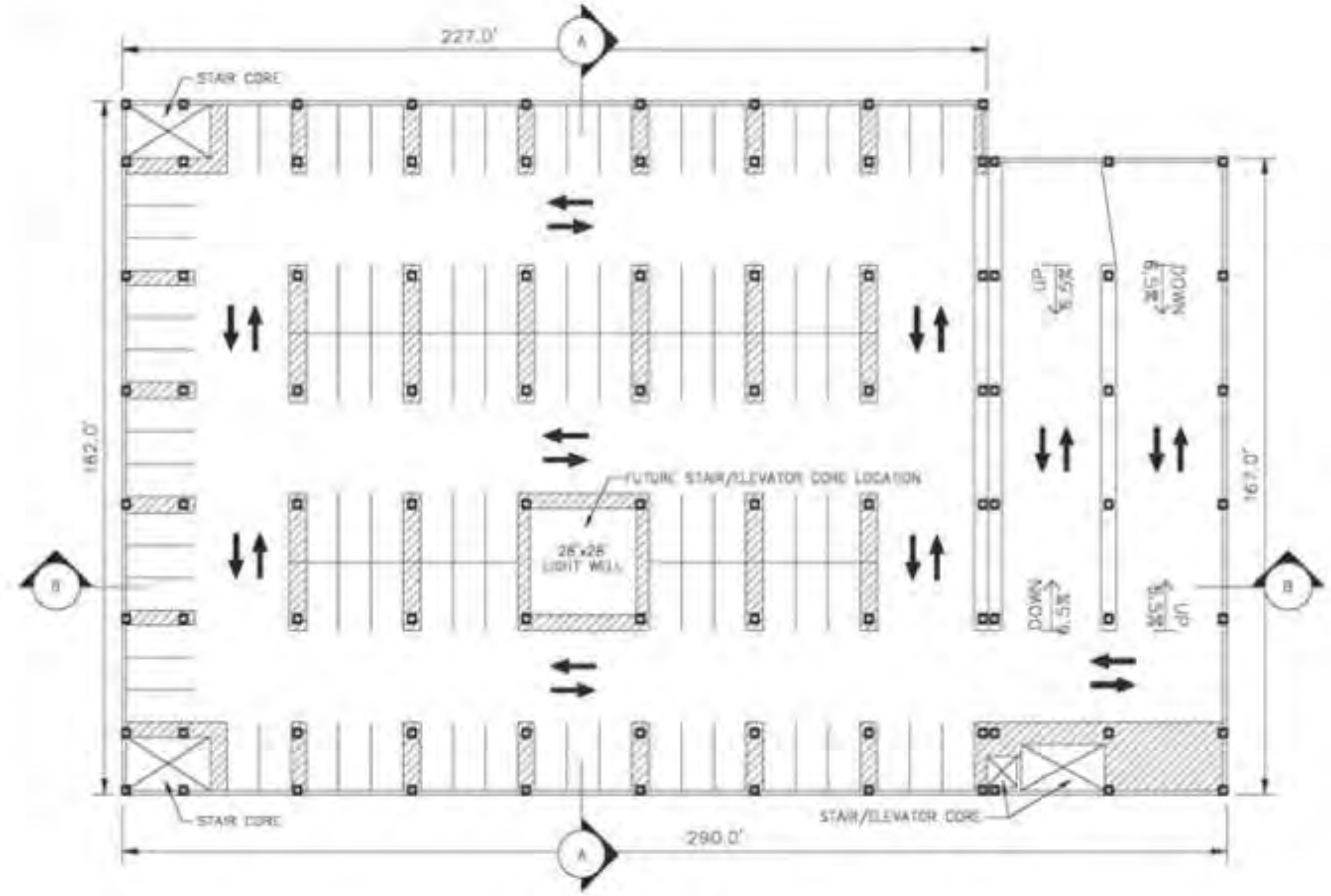
DRAFT 12/05/2016

Kimley»Horn

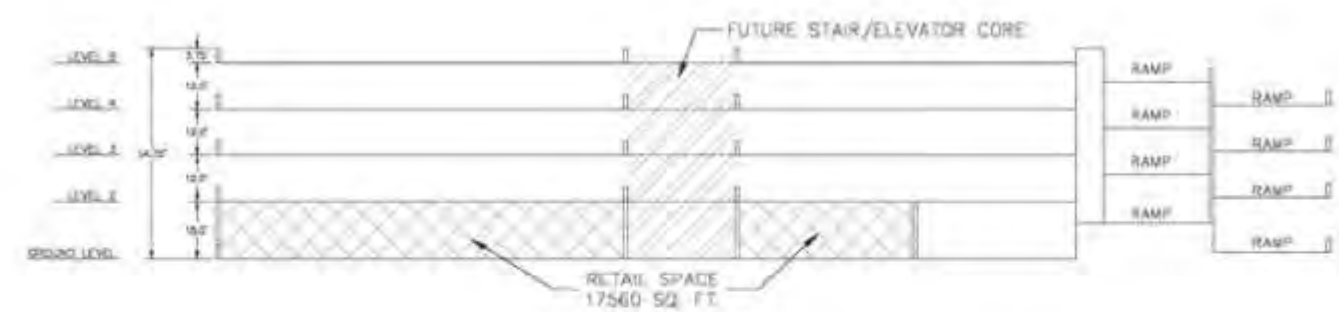
CONCEPT 2: NEAR-TERM USES



GROUND LEVEL



TYPICAL LEVEL



SECTION A–A

SECTION B–B

PARKING STALL COUNT SUMMARY

LEVEL	SPACES	AREA (SF)	PARKING EFFICIENCY	RETAIL AREA (SF)
GROUND LEVEL	58	29804	514	17560
LEVEL 2	109	51835	476	–
LEVEL 3	109	51835	476	–
LEVEL 4	109	51835	476	–
LEVEL 5	109	51835	476	–
TOTAL	494 *	237144	480	17560

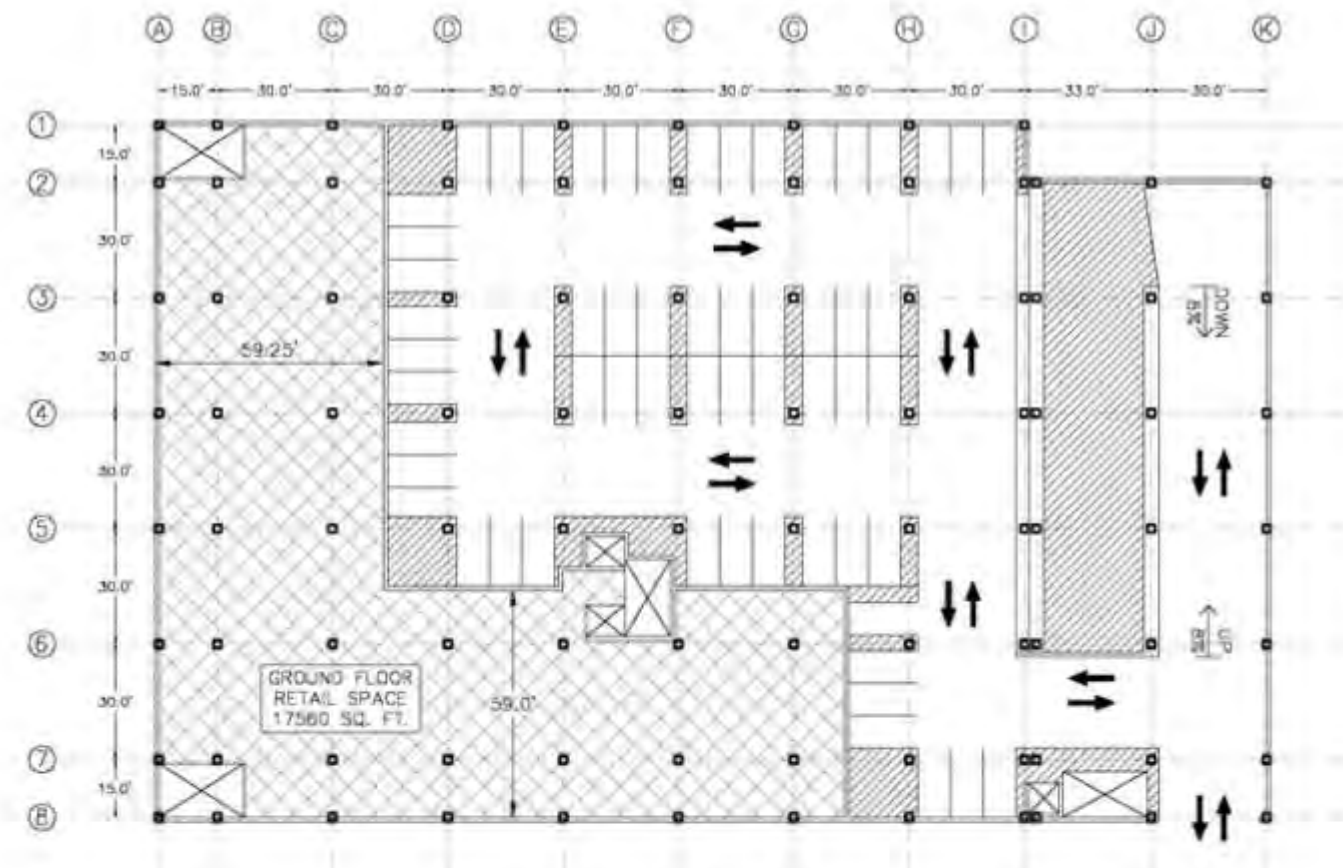
* THE TOTAL NUMBER OF SPACES HAS NOT BEEN REDUCED TO ACCOUNT FOR LOSS OF SPACES DUE TO ADA ACCOMMODATION, MOTORCYCLE PARKING, AND UTILITY AND STORAGE ROOMS.

SHEET 2A

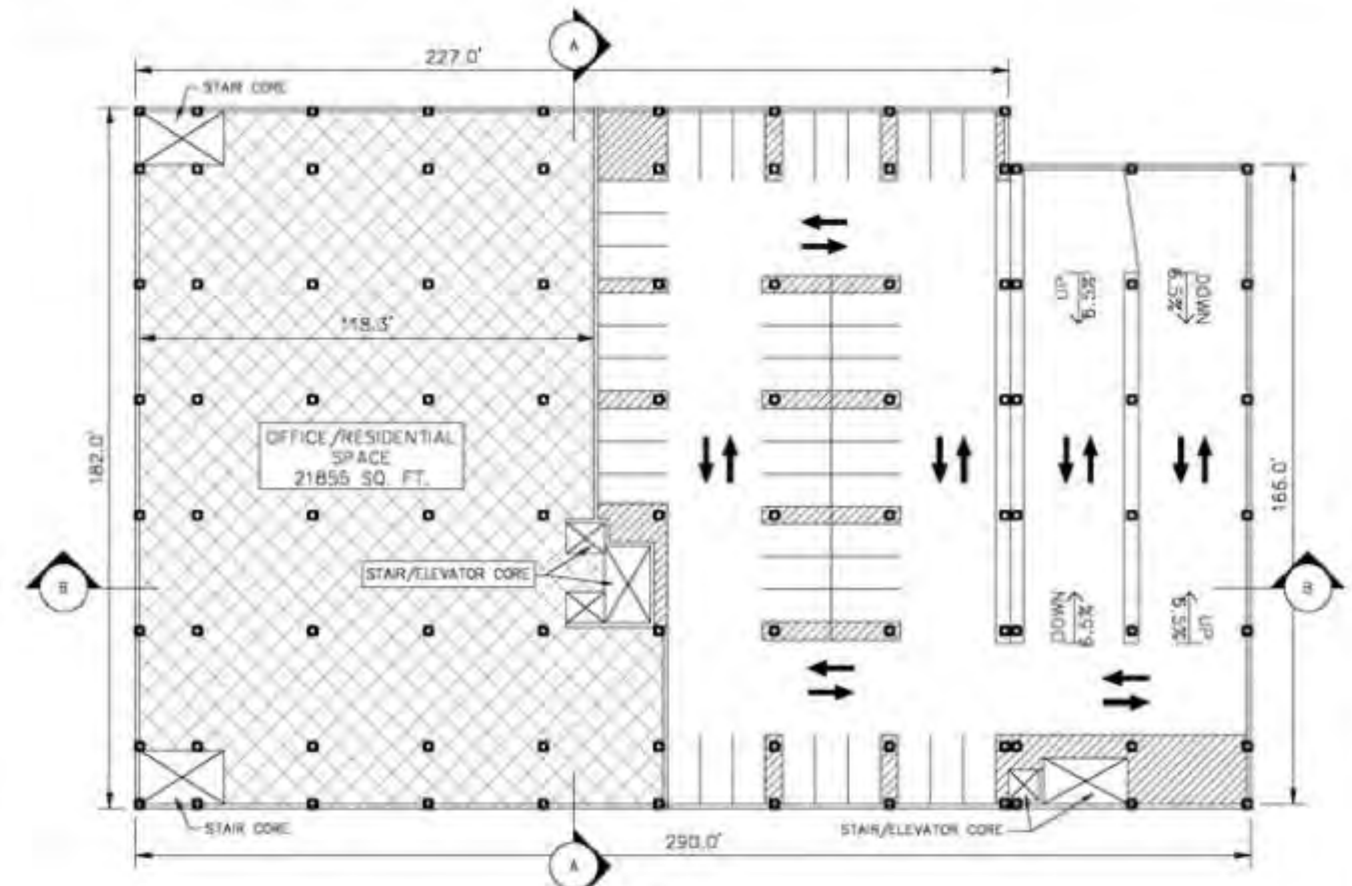
Kimley»Horn

DRAFT 12/05/2016

CONCEPT 2: FUTURE BUILDING USES



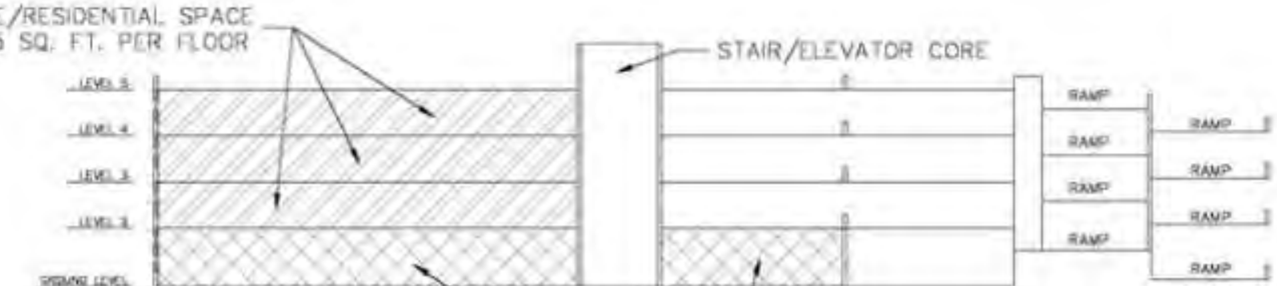
GROUND LEVEL



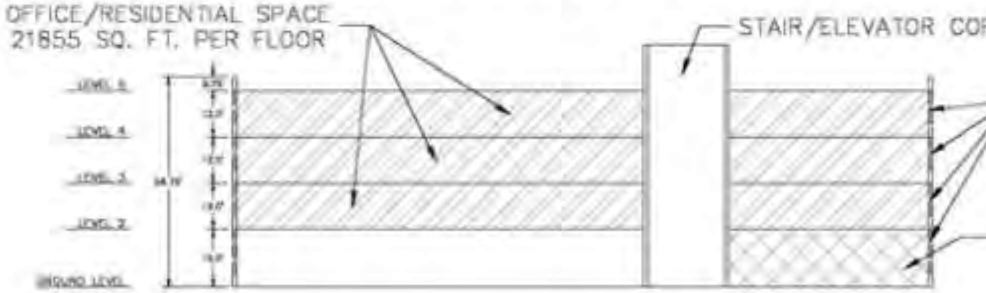
TYPICAL LEVEL

PARKING STALL COUNT SUMMARY					
LEVEL	SPACES (8.5'x18')	AREA (SF)	PARKING EFFICIENCY	RETAIL AREA (SF)	OFFICE/RESIDENTIAL AREA (SF)
GROUND LEVEL	58	29804	514	17560	—
LEVEL 2	45	29120	647	—	21855
LEVEL 3	45	29120	647	—	21855
LEVEL 4	45	29120	647	—	21855
LEVEL 5	109	51835	476	—	—
TOTAL	302 *	168999	560	17560	65565

* THE TOTAL NUMBER OF SPACES HAS NOT BEEN REDUCED TO ACCOUNT FOR LOSS OF SPACES DUE TO ADA ACCOMMODATION, MOTORCYCLE PARKING, AND UTILITY AND STORAGE ROOMS.



SECTION A-A



SECTION B-B

SHEET 2B

Kimley»Horn

DRAFT 12/05/2016

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Appendix 9

Parking and Access Management Program Financial Plan Template

For Municipal Parking Programs

Report Version: 1.0

Prepared for:

DMC Transportation & Infrastructure Program
City of Rochester, MN

Prepared by:

Date:12/20/2106
DMC Project No. Rochester J8618-J8622 Parking/TMA Study

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Parking and Access Management Program Financial Plan Template

Background

As was noted in a related deliverable (Parking and Economic Development Policy), during the meetings in November 2016 with City and Mayo Clinic transportation staff to assess current parking and access management programs, the DMC Plan guiding principle of developing "a comprehensive strategy to drive economic development and investment" was discussed. A related approach that also received interest from staff was the development of a defined parking and access management system financial plan.

The following document is a draft template for developing such a document the City of Rochester. This template is being provided as a resource document for staff to review. If the City staff feel this approach has merit and chooses to pursue a version of this approach for the Rochester community, we will develop a customized financial plan document that will be tailored specifically for the City of Rochester in support of the larger DMC plan and designed to support the DMC guiding principles noted below:

- Establish a Bold and Compelling Vision for Rochester and the Destination Medical Center
- Sustain Rochester and Southeast MN as a Destination Medical Center and Economic Engine for the State
- A Comprehensive Strategy to Drive Economic Development and Investment
- A Market-Driven Framework and Strategies
- A Dynamic and Accessible Urban Core
- Develop Mobility and Transit Solutions to Support Growth
- A Model for Sustainability
- Technology and Innovation to Promote a Globally Competitive Destination

Overview

For large municipal parking programs, having a detailed and well-defined financial plan is considered an industry best practice. The program financial plan would ideally address the following major elements:

- Program Overview
- Program Background
- Planning and Policy Framework
- Key Operational Objectives
- Fund Balance and Reserve Policy
- Uses of Parking Revenues Policy
- Debt Policy
- Rates Policy
- Annual Updates

Financial Plan Template

The following document is a template for developing a recommended parking system financial plan (with sample text for illustrative purposes only).

Introduction

Brief description of the parking programs origins, history and purpose.

Example text:

The City owned parking garage system was established in the 19__'s to meet a number of City objectives including downtown economic vitality, providing a balanced transportation system, and financial stability. The garages have been very successful in meeting these objectives, as noted elsewhere in this Plan. However, the City, and the parking garages, find themselves in a very dynamic environment. Careful planning is essential if the system is to continue to fulfill its mission, and do so in a financially sound manner. This Financial Plan establishes the financial policies and procedures that will ensure the operational and financial success of the system.

Background

The City of ________ owns five parking garages in downtown _______. They are:

Garage A	550 spaces
Garage B	700 spaces
Garage C	350 spaces
Garage D	541 spaces
Garage E	723 spaces
Total	2,864 spaces

All of these facilities are in the Parking Facilities Fund. Planning is underway for a sixth garage.

The City has contracted with _Company X_ since (date) to provide day-to-day management of the garages. Company X in turn has a number of subcontracts to provide operations, security, janitorial, sweeping, and marketing services for the garages. Company X also manages the City's parking validation program.

The garages are known as the _(Parking System Brand Name)_ garage system, and have a logo with that name and symbol.

Usage at the garages has grown rapidly in recent years, especially since we began the _(Parking System Brand Name)_ marketing program X years ago. The garages are full frequently during the peak weekday hours from 10:00 a.m. to 4:00 p.m. Usage has also grown dramatically in the evening and weekend periods. As a result, the financial condition of the garages is strong, and getting even stronger. We have been able to catch up with all deferred maintenance, and are now on a regular capital maintenance schedule.

The garages also include some commercial retail space at (insert locations). This is managed by the (insert department or agency). Rates and policies are set by (insert department or agency) in accordance with standard industry practices in downtown _____.

If parking revenues are used to fund other community initiatives or programs, note here. Also include financial contributions or debt obligations if applicable.

Another element that could be addressed here are policies regarding the use of Parking Facilities Fund. See example language below:

"Annual debt service expenditures will be paid from parking system revenues. Short-term parking rates were recently increased by $__/hour to assist in paying this increased cost. The rate increase generates an additional $__ million per year. The remainder of the debt service obligation will be paid from existing net revenues of the parking system.

Additional policy statements or guidelines related to Parking Facilities Fund financial policies could be inserted here. Also noted below are examples of "qualifying statements" related to use of parking fund policy decisions. See example language below:

1. Resources of the Parking Facilities Fund will be sufficient to fully meet system expenditures and the debt service requirements associated with approved parking fund contributions. However, adding a new garage may require an additional increase in short-term parking rates depending upon the terms of the new facility.

2. The reserve for future construction will decrease over the forecast period. It will not reach its desired maximum of $__ million until after bonds on ______ garage and _____garage are paid off in _year x – year y_ and year x – year y _ time frames. However, reserves for major maintenance and operations will remain fully funded throughout the forecast period.

3. Council's decision to use the Parking Facilities Fund's net revenues for the _note special project name_ results in the probability that the fund, at current rates, will not be able to finance other transportation projects in the Central City for at least the next ten years. Neither will it be able to subsidize or otherwise assist Central City projects such as housing or a project in the ________ District.

4. The possibility still exists that an economic downturn could affect usage at the garage. Also, the financial performance of any new garage is uncertain. While the Fund Projection and this Financial Plan use relatively conservative assumptions, a worst-case scenario could have serious consequences, since there would not be as much financial flexibility in the Fund.

Planning and Policy Framework

This section of the Financial Plan describes the planning and policy framework that the financial plan is designed to support. It should address the mission for the system and identify specific tasks that need to be accomplished to ensure the continued success of the system. One of those tasks could be the completion of a Financial Plan as this document.

Following is more example language and key recommended section elements such as a strategic mission statement, alignment with larger plans, preparation of an annual capital plan, preparation of a long-range major maintenance plan, development of an annual fund projection, etc.

The Parking System Strategic Plan Mission Statement is:

Our mission is to support the economic vitality of the Central City by providing an affordable system of parking garages which primarily meets the short-term needs of shoppers, visitors and business clients and by investing in other Central City transportation improvements.

In _(year)_, the **_______ Plan** was completed. This Plan established a number of strategies needed to ensure that the _(Parking System Brand Name)_ system continues to meet the demand for parking in the Central City. These strategies include construction of new facilities, restriping, rate adjustment, provision of bicycle and carpool parking, and other demand management techniques. This Financial Plan helps the City to ensure that we can afford all necessary strategies without undue risk.

In _(year)_, the **_ (larger parking or downtown strategic plan or master plan)_** was completed. The XXX Plan is a part of a continuous planning process intended to promote economic vitality, livability, and environmental quality for Central City residents, workers and visitors. According to the XXX Plan, parking structures are the preferred method of providing parking in the Downtown to promote a compact and walkable urban environment. New parking structures will be built to promote the use of alternative transportation, such as transit and carpool, to support existing and new economic development and to enhance the urban form of the Central City. Implementation of this Financial Plan would be consistent with policies of the XXX Plan.

All City divisions with capital assets are required to prepare an annual **Capital Improvement Plan**. The _(parking department)_ has prepared such a plan for the garage system each year. The focus of this plan has been primarily the scheduling of major maintenance projects, so that they are completed in a timely manner, but in a way that minimizes the financial impact in any one year.

In _(year)_,, the _(parking department)_ completed a detailed **Long-Range Major Maintenance Plan** for the garages. This plan identifies each of the major subsystems of the garages (elevators, electrical, structural, etc.). It notes the maintenance history of each and forecasts the maintenance needs of each for the next twenty years. It estimates the cost of each, and totals the costs by year so that we know how much we must plan to spend to ensure that each will continue to perform its function reliably.

For a number of years, the _(parking department)_ has prepared a **Fund Projection** that forecasts revenues and expenditures for the system for the coming five years. This financial planning document helps us to ensure that the system's financial health is maintained. This Financial Plan incorporates the Fund Projection and will provide the basis for its future updates.

The current Fund Projection incorporates the following assumptions:

a. Parking revenue grows at __%, without a rate increase. This is due to increased demand, especially increased demand during off-peak (evening and weekend) periods.

b. Commercial rent revenue grows at less than __%.

c. Operations and maintenance expenses grow at __%. This is approximately the long term Portland area CPI for this type of expense

d. Debt service is the established payment schedule for each of the debt issues.

e. CIP's are the annual average expenditure required for each garage and was determined by the _(year)_ major maintenance study.

Overall, parking revenues have grown in recent years by about __% per year. The reasons for this substantial growth include:

a. the growth in downtown retail

b. the very effective _(Parking System Brand Name)_ marketing program

c. effective management

d. the high level of customer service the system provides

e. reasonable rates

f. reliable availability of short term parking

g. the _(Date)_ rate increase from $__ to $__ per hour

Expenditures have grown about __-__%. This expenditure growth is due to:

a. inflation

b. increasing maintenance needs of an aging system

c. increased staffing to serve the growing number of customers

The difference between the revenue growth and expenditure growth is reflected in the increase in the size of the Fund Balance. This Fund Balance has in the past constituted the system's operating and maintenance reserves, and has been the resource for system expansion, in particular, the two-story addition to the ________ garage.

Operational Objectives

This section of the Financial Plan describes the system's operation objections. The program's basic objective is to accomplish the _(Parking System Brand Name)_ Mission. See example language below:

The following strategies applied to achieve the program vision and mission:

a. High quality customer service. Specifically, this means such things as ensuring an adequate number of well-trained attendants to provide courteous, efficient service when a customer leaves. We want to minimize the length of time they must wait, and to make their interaction with the program as pleasant as possible. In addition, we want them to feel safe and secure in the garage, and want them to have as clean and well maintained a facility as possible. This level of service gives us satisfied customers who will return to the garages and recommend us to their friends.

b. High quality maintenance. This means keeping the elevators operating virtually non-stop, replacing burned out lights promptly, repairing damaged sections of the garage quickly and completely, removing graffiti promptly, etc. It also means ensuring that the major and very expensive subsystems of the garages (lighting systems, structural systems, revenue control equipment, etc.) are repaired and/or replaced on a regular basis. Again, customers will feel more comfortable knowing that their garage can be relied on to function safely and effectively. We also keep our maintenance costs as low as possible by staying current and not having to fund inherently costly deferred maintenance projects.

c. Effective marketing. _(Parking System Brand Name)_ operates in a very competitive environment. As part of downtown, we compete with the suburban malls for shoppers. For those motorists who do come downtown, we compete with privately owned garages and on-street meters, especially on evenings and weekends. We also face the challenge of the relatively widespread but incorrect perception that downtown parking is unavailable, inconvenient, expensive, and generally a hassle. We must sell the convenience and attractive price of _(Parking System Brand Name)_ if we are to meet our mission. Thus an aggressive marketing program is essential.

d. Effective management. The _(Parking System Brand Name)_ provides a consistent, high quality level of management service. Through careful planning and attention to detail, we have ensured that customers have received the service they expect and the City demands. _(Parking System Brand Name)_ has also provided careful and effective coordination with the downtown business community, which depends heavily on the success of the garages to promote their own business objectives.

e. Planning and Development. The _(Parking System Brand Name)_ and related agencies and partners assesses parking demand and develops funding and development strategies on an on-going basis to ensure critical parking needs are met.

Fund Balance/Reserve Policy

This section of the Financial Plan describes the system's policies related to "fund balance and financial reserve policies". See example language below:

The Fund will maintain three reserves:

1. An operating reserve of 10% of one year's total budget, not counting debt service.
2. A major maintenance reserve of one percent of the replacement value of the garages.
3. A capital construction reserve. Its size will be determined as described in the Annual Update.

Operating Reserve

The operating reserve standard is the level recommended by the Government Finance Officers Association. They recommend 5-10% depending on the level of risk. The appropriate point on that range depends on our assessment of the nature and degree of financial risk for the system. The risks to the City in the parking business are relatively high. They are:

a. _(Parking System Brand Name)_ operates in a competitive environment, which is rare if not unique in government. The competition comes from privately owned garages, parking meters, and especially suburban malls where parking is free. An economic downturn or other financial distress suffered by downtown business would be directly reflected in parking garage usage and revenues.

b. The City is in the parking business because we are expected to take on a level of risk that the private sector is not willing to assume. Parking in general is not inherently profitable if the rate is to remain affordable. In fact, the City's experience in all of our garages shows that we must expect losses in the early years if not the life of the garage debt. Affordable parking is critical to the success of downtown. Our rates must always be below market so that this important public objective can be achieved.

Given this inherently risky financial environment, a relatively high reserve is warranted. It will ensure that the system continues to remain financially healthy almost regardless of the social or economic environment.

The operating reserve will be used for the following purposes:

1. To maintain service levels when economic, social, or other conditions cause usage and revenues to decrease.

2. To fund investment opportunities that will allow the City to take advantage of business opportunities that will increase service and/or reduce costs.

Major Maintenance Reserve

The major maintenance standard is similar to one used in State statutes that sets reserve requirements for non-general fund facilities. Facilities such as parking garages that are exposed to the elements are especially prone to maintenance problems. Industry standards suggest that parking facility maintenance reserves should be in the range of $75/space/year. If we are to maintain a high level of reliability and customer service, we must be able to respond to any maintenance problem quickly. This reserve assures our ability to do so. Note that this reserve is in addition to the ongoing maintenance budget for the garages.

The maintenance reserve will be used for the following purposes:

1. To fund one time, emergency, or unanticipated expenditure requirements that cannot be covered by the major maintenance or operating budget.

2. To maintain major maintenance project funding levels in the event of unanticipated revenue reductions.

3. To provide adequate cash flow when major maintenance projects exceed the annual average for them established in the CIP and major maintenance plan.

The Fund will not maintain a replacement reserve. By completing major maintenance projects each year replacement of the facilities can be deferred for a substantial period of time.

If the operating and maintenance reserves are lower than these amounts the Fund will use higher than budgeted revenues and/or lower than budgeted expenditures to replenish the reserve. If within one year the reserves are not replenished to the levels required by this Plan, the City will raise rates in an amount sufficient to bring them up to those levels within two years.

Capital Construction Reserve

The purpose of the Capital Construction Reserve is to fund, in part, the construction of new parking facilities. The City's experience shows that a new facility cannot be built and operated at a break even basis for a long period of time, if at all, given the rate policy that we have adopted. Accordingly, a reserve is needed to provide the subsidy needed to allow a new facility to break even. If the capital construction reserve is not fully funded, _(Parking System Brand Name)_ will evaluate the Fund Projection as part of the Annual Update to determine if forecast net revenues of the system will be sufficient to provide the cash financing needed for new facilities, by the time those facilities are forecast to be needed. If the Update shows that the Reserve will not be fully funded, the City will consider raising rates to fund it. This increase may occur prior to the expected construction of the new facilities. However, if an early rate increase would have a negative impact on the achievement of the Mission and Goals of the system, the increase may be deferred until needed to pay debt service and operating expenses of the new garage.

Policies Regarding Uses of Parking Revenues

This section of the Financial Plan describes the system's policies related to "policies regarding the approved uses of parking system revenues". See example language below:

Expenditure Policies

1. The City will continue its policy of spending sufficient funds on basic services such as attendants, security, janitorial, minor maintenance, and marketing to ensure that customers consistently receive a very high quality level of service.

2. The City will continue its policy of carefully planning and funding major rehabilitation and maintenance of the garages so that they will continue to provide a high quality, consistent, efficient, and reliable

service for the indefinite future. The City will update and implement those plans each year.

3. All expenditures will be consistent with the System's values established by the Strategic Plan, and will support the Mission and Goals set by the Strategic Plan.

4. The priority for the use of parking system revenues is as follows, and as reviewed in the Annual Update.

a. Operations and maintenance of all garages.

b. Debt service on the garages.

c. Funding the garage Operating Reserve and Major Maintenance Reserve.

d. Debt service on the bonds to which parking revenues have been committed to (if applicable).

e. Continuation of the ongoing transfers to other funds (if applicable) adjusted for inflation. However, if future City financial plans show that these transfers are no longer necessary, or are no longer the most efficient way to meet City expenditure requirements, this priority may be changed.

f. Funding the Capital Construction Reserve.

g. Funding other parking and traffic improvement projects, and assisting other Central City improvement projects such as high density, affordable housing, as allowed by state law.

Policy Regarding Determining the Amount of a Fair Return

In some communities, the City Attorney has advised the City that state statutes allows payment to the City of a fair return on its investment in a facility for the purpose of making additional parking and traffic improvements. The attorneys also advised that the determination of what a fair return means in dollars is an administrative decision.

There are two approaches to determining the amount of a fair return.

1. A conservative approach would be to use the Comprehensive Annual Financial Report (CAFR) values to determine the amount of the investment, and use the Public Utility Commission (PUC) formula for rate of return for regulated utilities (9.6%) as the rate of return.

2. Another approach would be to use replacement, or market value, and the PUC rate of return.

Use of CAFR values seems excessively conservative, because they do not reflect the true market value of the property. If the City were to sell the garages the net proceeds would be construction cost of an equivalent facility, plus land value, less depreciation and outstanding debt. This suggests that the market value approach is more realistic. Accordingly, the policy is that the amount that is made available for these improvements is limited to the rate of return allowed by the PUC for regulated utilities, applied to the market value of the garages. The City may raise rates to fund these projects, consistent with the other goals and policies in this Plan and other Plans. The policy by which specific parking and traffic improvements will be funded will be established in the Annual Update.

Debt Policy

This section of the Financial Plan describes the system's policies related to "debt policy" related to the parking system". See example language below:

The City of ______'s Debt Policy will govern the debt policies and practices of the Parking Facilities Fund. An important feature of parking system debt is that the revenues of each of the garages in the Fund are cross pledged to the bondholders of the other garages debt. Another feature is that the coverage ratio for parking garage debt is enhanced by the pledge of net parking meter revenues.

The City has consistently used the net revenues of the downtown core garages to cover the financial shortfalls of the _________ garage(s), and will continue to do so. However, the City has never needed to use net meter revenues to support the garage debt or operations. It is the City's policy that the garages will be managed in such a way that whenever possible net meter revenues will not be used in that way in the future.

The coverage ratio required by the bond covenants varies, but is averages approximately 1.5. It is the City's policy that the Fund will achieve the ratio on its own, without use of net meter revenues, whenever possible.

Rates Policies

This section of the Financial Plan describes the system's policies related to "rate setting" related to the parking system". See example language below:

Rates will be set to achieve the following objectives:

1. To meet the system's objectives.
2. To ensure the financial health of the system.

3. To ensure that parking is affordable for downtown visitors and businesses.

4. To implement the City Council's parking and transportation objectives.

The most important rate is the basic rate for short-term (less than four hours) daytime parking. This rate will be as low as possible to maximize objectives #1 and #3 above. It will be raised as little as possible, and only when needed to meet objectives #2 and #4. Short-term rates will be below market. Only City Council Resolution or Ordinance will adjust short-term rates. (This last statement should reflect local policies. Many programs have an internal board that are authorized to make rate setting decision without council or ordinance approval requirements.)

The City will consider the need for an additional increase in the parking rates as part of the analysis of specific projects to site and build or acquire a new downtown garage. The City will account for the cost of land, cost of construction, financing costs and related issues in determining the need for such an increase.

The rate for long-term parking (greater than four hours) and the all day maximum will be as high as necessary to ensure the availability of employee parking. Generally, long-term rates will be set at the market rate for the area.

The rate for evening parking will be set to achieve all four objectives. Market rates will be a consideration. This means that we will try to be consistent with the market to maximize revenues, but not if it discourages potential customers from coming downtown for events.

Carpool rates for each garage will be set at 75% of the monthly rate for that garage.

Annual Updates

This section of the Financial Plan describes the system's policies related to "annual updates". See example language below:

Each year the _(Parking System Brand Name)_ will complete an update of this Plan. This update will:

1. Determine whether or not the system is meeting the Operational Objectives described in this Plan. If not, the update will include a plan to achieve that objective.

2. Determine whether or not the system's coverage ratio meets or exceeds 1.5. If it does not, the update will include a plan to achieve that objective.

3. Determine whether or not the Ending Fund Balance is sufficient to fund the system's operating and maintenance reserves. If it is not, the update will include a plan to achieve that objective.

4. Determine if the Balance is sufficient to pay other debt commitments. If it is not, the update will include a plan to achieve that objective.

5. The Annual Update will assess the need to build additional parking facilities. These could include any project consistent with the Strategic or Facilities Development Plans. If there is such a need, the update will include an estimate of when they will be needed, how much they will cost, and will establish a funding strategy. The strategy will calculate the amount per year that will need to be set aside to fund the new facilities. For example, if \$5,000,000 is needed 5 years from now, \$1,000,000 of the remaining net revenues will be placed in the Capital Construction Reserve. This Reserve will be set aside to offset the cost of the new facilities.

6. The update will also assess the need for other parking and traffic improvements that may be funded by the Parking Facilities Fund, as allowed by state law. Any funds in excess of the amount needed for the Capital Construction Reserve will be available for other parking and traffic improvements, as allowed by state law. If the Parking Group determines that these improvements have a priority over the funding of the Capital Construction Reserve, it may make findings to Council to that effect in the Annual Update.

Resolution

Approve a Strategic Plan and a Financial Plan for the City owned _(Parking System Brand Name)_ parking garages.

WHEREAS, the City owned _(Parking System Brand Name)_ parking garage system has been very successful in recent years in meeting the growing demand for short term parking while at the same time strengthening its financial condition.

WHEREAS, continued demands to increase the supply of parking and to assist with the financing of other transportation objectives strengthen the need for careful financial planning to ensure that the system will continue to successfully meet its objectives.

WHEREAS, the _(Parking System Brand Name)_ , has carefully drafted these Plans to ensure that all system and City objectives are met.

NOW THEREFORE BE IT RESOLVED, that the City Council adopts the attached Strategic Plan and Financial Plan effective immediately, directs that they be used to guide decisions regarding the _(Parking System Brand Name)_ system, and calls for the Annual Updates to be completed as detailed in the Financial Plan.