City of Santa Monica®

Information Item

Date: May 5, 2010

To: Mayor and City Council

From: Lee E. Swain, Director of Public Works

Subject: Feasibility of an Automated Parking Structure for Parking Structure No. 6

Introduction

On November 10, 2009, after a discussion of concept massing and cost implications for rebuilding Parking Structures No. 1 and 6, the City Council directed staff to return with information on automated parking systems and the feasibility of constructing an automated parking structure at the site of Parking Structure No. 6.

Discussion

Following the November meeting, International Parking Design, Inc. (IPD), the design-build parking consultant for the new Parking Structure No. 6, researched automated parking systems, visited several automated parking garages on the East Coast of the United States, and interviewed owners, manufacturer's representatives, and parking patrons associated with these automated parking garages. IPD also analyzed the City of Santa Monica's parking data and met with several City departments including Finance, Public Works, Housing & Economic Development, Planning & Community Development, and Fire to obtain input on possible automated parking system implementation at the new Parking Structure No. 6.

The attached report prepared by IPD provides a brief description on the history of automated parking systems and their operations. The report provides a general comparison between automated parking facilities and self-parking facilities, including IPD's research on automated parking facilities from their visits to the East Coast. The

report also provides a site-specific analysis for Parking Structure No. 6 and IPD's recommendations.

In short, the automated parking system in the United States is a fairly new industry and presents both opportunities and challenges. Systems are being used for parking projects that are situated on small or irregularly-shaped properties where a self-parking structure will not physically fit due to ramping requirements and at sites that do not experience large vehicular peak entry or exit volumes.

Currently, the seven completed automated parking structures in the United States have between 24 and 314 spaces. The new Parking Structure No. 6 is anticipated to have between 580 to 700 spaces to meet the demands of downtown business patrons. Vehicle calculations prepared by IPD based on current City parking data indicate that if an automated parking structure were to be built at the site of Parking Structure No. 6, vehicles would enter the parking structure faster than an automated system would be capable of processing them. Vehicles waiting to enter the parking structure would extend onto 2nd Street in the driving lanes. In addition, an automated parking system would not be able to deliver vehicles as fast as requested by exiting patrons during peak times, requiring a patron to wait up to 22 minutes before the vehicle could be delivered.

If an automated structure was built, there would be no space available for any ground floor retail or commercial lease area due to the necessary size requirements of the entry and exit compartments and the interior circulation. The lack of ground floor retail and commercial space on 2nd Street would deactivate the street and diminish the pedestrian experience.

Based on the firm's research, analysis, and visits to several completed automated parking facilities, IPD concluded that an automated parking system would not be able to accommodate the peaks, the high hourly parking needs, and the volumes of vehicles at the new Parking Structure No. 6, nor would an automated parking system meet the

expected level of service that downtown business patrons expect. IPD also determined that constructing an automated parking structure would result in approximately 35 percent higher costs than a self-parking facility.

A 250-space automated parking garage will be built in Santa Monica later this year by a private developer. Staff spoke with the developer who acknowledged that an automated parking system has not been tested in Santa Monica, but is hopeful that the issues of insufficient equipment operational speed will be resolved. Staff will continue to monitor this project. Data on the performance of this new private facility will inform possible future applications that may be more suitable for an automated solution.

Next Steps

Staff will present to Council in May the Guaranteed Maximum Price (GMP) agreement for full preconstruction and design services for a self-parking structure at the site of Parking Structure No. 6.

Prepared By: Karen Domerchie, Architectural Associate

Attachment:

A – Report prepared by International Parking Design, Inc. dated March 29, 2010

ATTACHMENT A

INTERNATIONAL PARKING **DESIGN**

International Parking Design, Inc.
14144 Ventura Blvd., Suite 100 Sherman Oaks, CA 91423
TEL 818 986 1494 FAX 818 906 8697 WEB www.ipd-global.com
Architecture / Engineering / Consulting

March 29, 2010

Ms. Miriam Mulder
City Architect
Architectural Services
1437 4th Street, Suite 300
Santa Monica, CA 90401

Re: Automated Parking Report
Parking Structure #6
City of Santa Monica
Santa Monica, CA

City Staff;

The purpose of this report is to respond to the City Council's request to evaluate and report back to the Council if an automated parking system will meet the necessary requirements for Parking Structure #6 so as to be considered a viable type of parking system for the new proposed structure accommodating an assumed 700 spaces.

I. BACKGROUND - AUTOMATED PARKING STRUCTURES

A. History

According to our research, there are currently seven completed automated parking facilities in the United States and nine that are presently under construction. See Exhibit A for a list of these facilities. The first automated structure in the United States was built in Hoboken, NJ in 2002. While there are many automated parking structures in Europe and Asia, the technology has been slow to develop in the United States.

Please see Exhibit B for articles on automated parking that provide an overview of the system and discuss the current state of development.

A list of different manufacturers, with their websites, is provided in Exhibit C.

B. Operation

A patron's experience of an automated parking structure begins as the patron drives into an enclosed entry compartment and parks, precisely aligning their vehicle with the help of sensors and lasers. The patron gathers their belongings and exits the vehicle. The patron takes a ticket from a machine outside the compartment, triggering the compartment door to close. Sensors detect if there is any movement in the vehicle (from children or pets), and will refuse to take the vehicle if motion is detected. If no motion is detected, the system will store the vehicle. When exiting, the patron goes to a centralized location, puts the ticket into a machine, and the system retrieves the vehicle. An interface informs the patron which exit compartment the vehicle will be arriving in, the patron goes to the compartment, enters the vehicle, stores their belongings, and drives out of compartment. The compartment is then ready to service another vehicle.

Additional automated parking terms and definitions are provided in Exhibit D.

II. GENERAL COMPARISON OF AUTOMATED PARKING AND SELF PARKING FACILITIES

As with any selection of options, there are trade-offs of features, priorities, functions, etc. The following is a general comparison of an automated facility and a self-parking facility.

Automated Parking Facility	Self Parking Facility
Smaller vehicle storage volume needed due to more efficient parking; can have tandem parking	Larger storage space needed due to ramping
Access design and queuing requirements will be greater in time & amount of vehicles	Access design and queuing requirements typically not an issue
Greater capital costs	Lower capital costs
Vehicle is secure from vandalism/ theft/damage as storage area is not accessible to patrons	Less secure from vandalism/theft/damage
Centralized waiting area for patrons	Patrons retrieve own vehicle
Not good for peak volume demands (e.g. retail, commercial & theaters)	Can accommodate peak volume demands
More employees required for unfamiliar users – entry and exit areas	Typically requires one employee for ticket booth
Minimum ventilation required in vehicle storage area	Mechanical ventilation required in enclosed vehicle storage areas
Higher electrical usage to run motors for system operation; minimal lighting for vehicle storage area	Electrical usage for passenger elevator motors; requires more lighting for vehicle storage area
Proprietary system – have to maintain service contract with manufacturer	No proprietary system
Machinery requires precise alignment, needs routine maintenance	No alignment issues; minimal maintenance

III. INVESTIGATION AND STUDY METHOD FOR PARKING STRUCTURE #6

A. Overview

We began our research with the most current articles from trade publications and literature from different manufacturers. I visited and interviewed owners, manufacturer's representatives and parking patrons associated with six automated parking installations. These structures were selected as the Northeast area of the country has the greatest concentration of completed structures. The site observations along with relevant articles and manufacturers' literature were shared and discussed with city staff from numerous departments, including Parking, Planning, Traffic Engineering, Building and Safety, Finance, and Fire.

In our research, we learned that in 2007 the City of San Luis Obispo had also considered an automatic parking system for a new approximately 500 space structure in the downtown retail area. Their consultant developed three conceptual designs, two of which were automated parking while one was ramped self-parking. The City of San Luis Obispo ultimately selected the traditional self-parking option due to cost concerns. Both capital and maintenance costs for an automated parking structure were double the costs for a typical ramped self-parking structure. See Exhibit E for the City of San Luis Obispo Council report.

B. Site Visits

Six automated parking structures were visited: two in Philadelphia (both were still in construction), two in Manhattan, one in Hoboken, NJ, and one in Washington DC. A write-up of the visited facilities can be seen in Exhibit F. Most of these existing automated facilities are very small, ranging from approximately 40 to 300 spaces (as compared to the anticipated 580 to 700 spaces for PS #6). Five of the structures visited were built on properties that could not accommodate the required number of parking spaces with a typical ramped self-parking structure. Of the four completed structures that were visited, only one serves hourly patrons in addition to monthly patrons. This structure requires a full-time employee to help guide users at the entry and exit compartments. The other three structures serve monthly users exclusively (residential).

C. Parking Calculations

The City's Parking Department provided data gathered by Central Parking for the City's current parking structures. From this data, the projected parking demand for the new Parking Structure #6 was extrapolated. The resulting demand determined the entering and exiting vehicle queuing for an automatic parking system as-well-as the self-parking system.

IV. PARKING STRUCTURE #6 SITE-SPECIFIC ISSUES & ANALYSIS – AUTOMATED AND SELF-PARKING STRUCTURES

City Staff identified priorities for Parking Structure #6. The following section responds to those priorities for automated and self-parking structure types.

The following analysis and comparison is based on a 700 space parking structure.

A. Minimize Vehicular Wait Times

Entering for Automated Structures:
In order for the amount of interior queuing spaces to be sufficient, the average entering rate of vehicles needs to be ~75% of the average entering capacity rate of the automated parking system. The vehicle entering calculations in Exhibit G indicate that the vehicles will enter the structure faster than the system is capable of processing them. During peak time, patrons may wait up to 14 minutes to have their vehicles parked.

Entering for Self-Parking:
Because the ticket dispenser can accommodate entering vehicles faster than the vehicles will arrive, patrons may wait up to 30 seconds. See entering calculations in Exhibit H.

Exiting for Automated Structures:
The vehicle exiting calculations in Exhibit I indicate that the automated system cannot deliver the vehicles as fast as requested by exiting patrons during peak times. Many patrons may have to wait up to 22 minutes in the waiting room for their vehicle.

Exiting for Self-Parking:
The wait time for exiting through the control lanes (based on one lane with a booth and one lane with a card reader) may be up to 2.5 minutes. See entering calculations in Exhibit J.

B. Minimize Queuing Impact to Street

For an automated structure, during peak times, vehicles will enter at a faster rate than they can be processed. Queuing for 45 vehicles is likely to be required. About 16 vehicles (see Exhibit K) could be queued inside of the structure. This leaves 26 vehicles queuing (about 520 lineal feet) out onto the street, affecting street and bus traffic flow. For exiting, at a processing exit rate of only about 3 vehicles per minute for the nine Exit compartments, there is no exit queuing problem as the street can accept them at that rate.

For a self-parking structure, entering queuing for 3 vehicles is required and provided in the structure. Exiting queuing for 8 vehicles is required and will be accommodated within the structure. See Exhibit L.

C. Minimize Number of Driveway Lanes at Street Curb

An automated parking system will require driveway widths of 53 feet along the street curb; two exit lanes and one entry lane. See Exhibit K.

A typical ramped self-parking structure will require driveway width of 53 feet along the street curb. See Exhibit L.

D. Minimize Capital Costs

We have analyzed projected costs for a 700 car self-parking structure and a 700 car fully automated parking structure.

For a self-parking structure there will be 3 levels below grade and 7 levels above grade. Above grade parking is approximately $20,000 per space and below grade parking is approximately $40,000 per space.

For a fully automated structure, a building enclosure is constructed by a contractor and the automated parking machinery and steel racking inside is built and installed by the manufacturer. For this study, we have averaged pricing from four manufacturers that have fully automated parking structures completed or in construction in the United States. The average projected cost from the manufacturers plus the projected cost of the building enclosure is approximately $35,000 per space. The automated parking structure would be all above grade.

The projected cost for a 700 car structure at the PS#6 site for an automated structure would be approximately $6.8 million more than the self-parking structure and thus would add a premium of approximately 35%.

E. Minimize Maintenance Costs

Information on long term maintenance costs is not addressed in this report. With just 7 installations completed in the United States with an average of under 5 years, we do not feel comfortable offering projections and comparisons at this time.

F. Provide Street-front Retail Area

For an automated structure, due to the necessary sizes of the entry and exit compartments and interior circulation, there is no space available for any ground floor retail/commercial lease area. See Exhibit K.

With a typical ramped self-parking structure, approximately 6,400 sf of ground floor retail/commercial space could be provided. See Exhibit L.

G. Consider Building Massing/Setbacks

For an automated parking system, the ground floor volume would fill the whole site, approx 150' by 200'. Above the ground floor, the 700 parking spaces could be accommodated in a volume 70 feet high, 100 feet deep and 200 feet wide. The vehicle storage tower would have a 30' setback from the 2nd Street property line.

A 700 space self-parking structure would require an above grade volume of 142' deep at ground level (130' deep above the ground level with an 18' set-back), 200' wide & 84' high as well as three possible levels below grade.

H. Operational Concerns

An automated structure could require four or five full-time employees to guide the parking patrons through the entry and exit process to keep the system moving as expeditiously as possible, since this parking facility is predominantly for hourly patrons such as shoppers, diners and theatre patrons who may be unfamiliar with the system. The number of staff needed to service the mechanical/electronic systems can range from one to possibly six full-time persons.

A self-parking structure would require one full-time employee to staff the ticket booth.

I. Reliability/Maintenance Issues

Several of the smaller new facilities that were visited said that they have a minimal need for mechanical or electrical parts to be repaired or replaced, but did provide monthly inspection/maintenance for a couple of hours in the early morning hours. About half of the facilities visited kept spare parts close by, while the other half relied on the manufacturer to respond within a contractual amount of time or they originally bought and installed redundant equipment to have ready in case of a breakdown.

A self-parking structure would have routine maintenance of the passenger elevators and parking equipment such as entry and exit arms and pay-on-foot machines.

V. RECOMMENDATION

The automated parking system in the United States is a fairly new industry and presents both opportunities and challenges. It is ideally suited to parking projects that are situated on small or irregularly-shaped properties where a self-parking structure will not physically fit. An automated system also works well for a parking facility that does not experience large vehicular peak entry and/or exit volumes. The reduced possibility for vandalism and vehicular damage to occur is also an advantage.

The Parking Structure #6 site and its role in the City's downtown area require that it will be able to accommodate the high hourly parking needs, peaks, and volumes of patrons and vehicles. Based upon our research, calculations, and visits to several completed automated parking systems, we do not believe that an automated parking system is capable of providing the capacity that will be required for the projected number of vehicles at the new Parking Structure #6, nor the expected level of service that downtown business patrons expect. The lack of ground floor retail/commercial space will deactivate the street and diminish the pedestrian experience. We also do not believe that paying a premium of approximately 35% for a relatively new type of product that will not meet the required capacity is a good economic choice. We therefore do not recommend an automatic parking system for this particular project.

There are other projects in Santa Monica that may benefit from this type of parking system. It may be ideal for projects that cannot fit the required number of parking spaces on an existing lot with a traditional self-parking facility. It may also be suited for monthly patrons, such as residents or low-volume office parking and may be an option for city staff parking.

Morley Construction Company and IPD thank the City of Santa Monica for the opportunity to provide parking consultation on the merits and drawbacks of an automated parking system for the consideration of a new parking facility at the Parking Structure #6 site in the City of Santa Monica. We trust that the included information will be helpful in the City's evaluation process. If you have any further questions or comments, we would be happy to answer or address them.

Respectfully,

J. Renard Bollier

Architect/Consultant

cc: Morley Construction Company

Encl.

List of Exhibits

Exhibit A – Automated Parking Facilities in the United States

Exhibit B – Selected Articles & Manufacturer's Literature

Exhibit C – List of Manufacturers and Websites

Exhibit D – Automated Parking Terms and Definitions

Exhibit E – Excerpt of City of San Luis Obispo Council Report

Exhibit F – Observed Automated Parking Facilities

Exhibit G – Auto Parking Structure #6 Analysis of Automated Entry "Processing"

Exhibit H – Self Parking Structure #6 Analysis of Automated Entry "Processing"

Exhibit I – Auto Parking Structure #6 Analysis of Automated Exit "Processing"

Exhibit J – Self Parking Structure #6 Analysis of Automated Exit "Processing"

Exhibit K - Auto Parking Ground Level Plan

Exhibit L - Self Parking Ground Level Plan

Exhibit M – IPD Corporate Brochure

Exhibit A

Status of Automated Vehicle Storage Systems in the U.S.

BY DON MONAHAN

AFTER COMPLETION OF THE first two fully-automated vehicle storage systems in mid-to-late 2002 (in Hoboken, NJ, and Washington, DC), it took another five years before the third system was completed in the U.S. (in New York City's Chinatown).

Although slow to catch on in the U.S., there has been a recent boom in the construction of these parking facilities. Today, nine systems have been completed or are nearing completion, and six more are under construction.

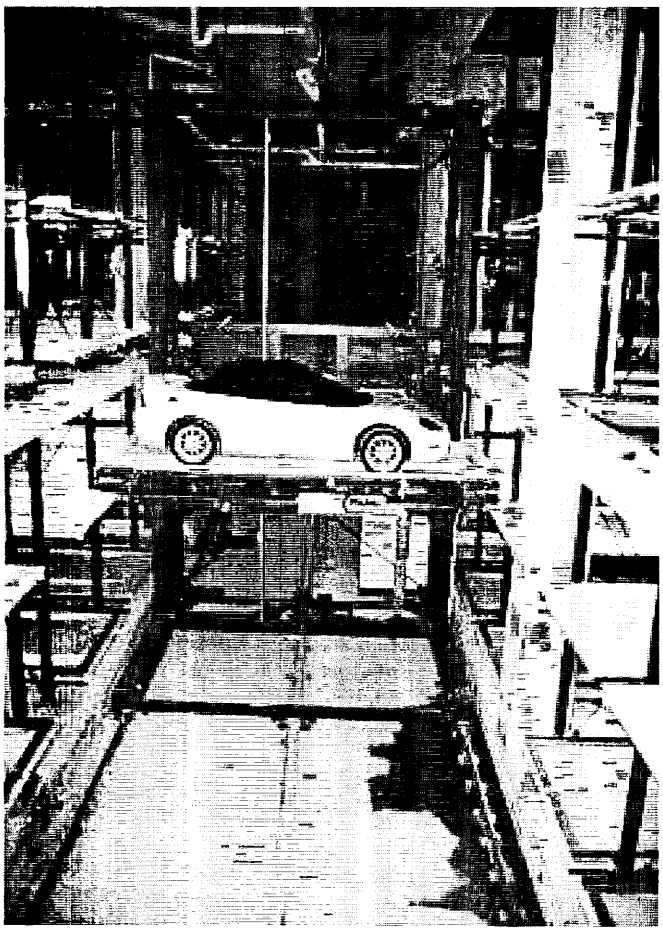


Figure 1 – Stacker Crane

The early AVSS projects in the U.S. used pallets to carry the vehicles. A recent trend in the industry moves away from palletized systems to non-pallet systems. Managing the storage and delivery of empty pallets is a headache. Also, non-pallet systems are often faster.

Continued on Page 22

Completed Automated Vehicle Storage Systems in the U.S.:

314 Spaces
916 Garden St., Hoboken, NJ
http://www.unitronics.com/Content.aspx?Page=Projects&id=28

40 spaces
One York, Manhattan
55 Avenue of the Americas, New York City
http://www.parkplusinc.com/projects.php

67 spaces
123 Baxter St. (Chinatown), New York City
http://www.adgorg.com/adg-project-baxter.htm

64 spaces
1706 Rittenhouse Square St., Philadelphia
http://www.scannapiecodevcorp.com/1706_rittenhouse.html

224 spaces
Juniper Street Garage
101 S. Juniper St., Philadelphia

24 spaces
418 Jessie St., San Francisco

74 spaces
Summit Grand Parc
900 15th St. NW, Washington, DC
http://www.spacesaverparking.com/projects/automaticparkingdebut.html

Automated Storage - **300 spaces**
Automated Vehicle Parking - **100 spaces**
Johnson Avenue, Coconut Creek, FL

Automated Storage - **300 spaces**
Automated Vehicle Parking - **140 spaces**
I-595 & U.S.-1, Fort Lauderdale, FL
http://www.robostorage.com/RoboVault-Storage-News_d150910f8.html

Status of Automated Vehicle Storage Systems in the U.S.

from Page 20

A non-pallet system consists of a dolly that slides under the vehicle. The dolly has steel arms that fold out and grasp the tires of the vehicle. The vehicle is lifted an inch or two off the floor and carried out of the entry compartment onto a horizontal shuttle that takes the vehicle over to a lift and up to a storage compartment.

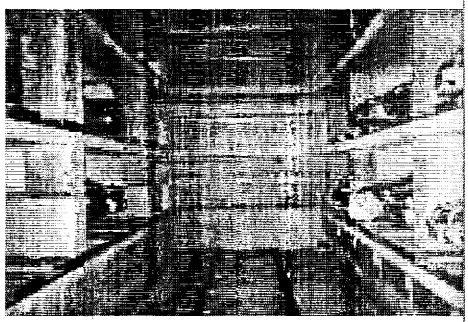


Figure 2 - Concrete floor design

In some systems the horizontal movement and lift mechanisms are provided in a single machine called a stacker crane (see Figure 1). All the machines are controlled by computer with no human intervention.

Where the floor area ratio (FAR) is not a consideration, there also is a trend away from steel storage racks to concrete floors (see Figure 2). The building codes do not adequately address fire protection and firefighter access for these building types, and some steel rack projects are having difficulty getting approved by building officials or fire marshals. The marshals find it easier to approve a concrete system because those systems have better fire resistance than do steel systems.

Where the FAR is a consideration, the open steel storage racks have an advantage in that there are no floors in the storage compartments. The vehicle is supported on a pallet that rests on the steel frame. Therefore, there is no floor area to count against the limit on FAR that is often present in zoning codes. The developer is then able to construct more building area.

The National Fire Protection Association is revising its Publication 88A, Standard for Parking Structures, to include a section devoted entirely to AVSS facilities. It should be available by mid 2010. By that time, 14 or more Automated Vehicle Storage Systems will likely be in use.

Don Monahan, P.E., a Vice President with Walker Parking Consultants, can be reached at don.monahan@walkerparking.com.

PT

Projects Under Construction:

270 spaces
1504 Coney Island Ave., New York City
http://www.aptparking.com/underconstruction.php

300 spaces
123 Beverly St., Boston
http://www.aptparking.com/underconstruction.php

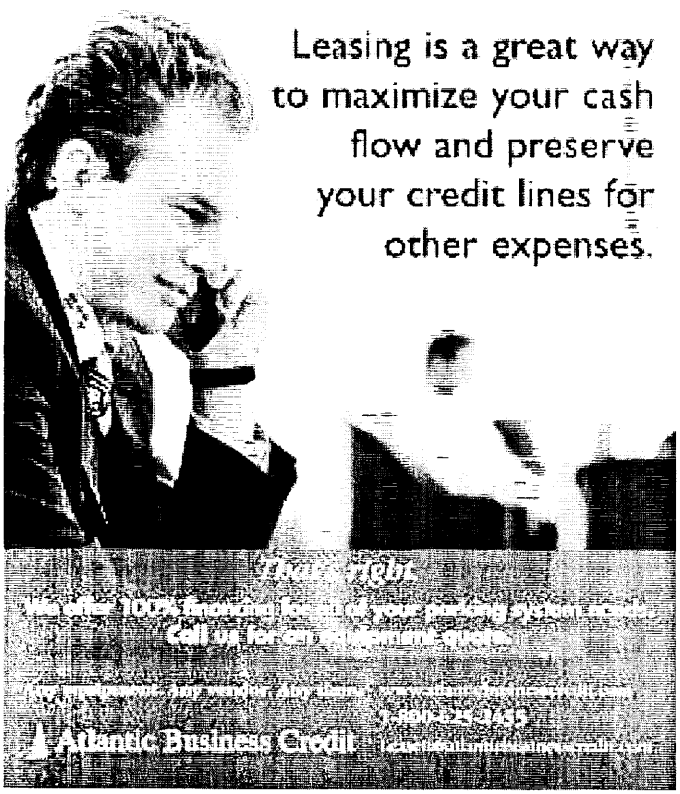
409 spaces
The Palisades of Towson
212 Washington Ave., Towson, MD
http://www.parkplusinc.com/projects.php

53 spaces
148 E. 24th St., New York City
http://www.automotionparking.com/24th.php

132 spaces
275 Seabreeze Ave., Brooklyn, NY
http://www.automotionparking.com/275Seabreeze.php

65 spaces
20 Grand St., Brooklyn
http://www.automotionparking.com/20Grand.php

Did You Know?



See PT three weeks early at parkingtoday.com

Exhibit B

Selected Articles and Manufacturers' Literature

Cudney, Gary. "Automated Parking: Is It Right For You?" *Parking Today* May 2003.

Munn, Charlie. "Past Hoboken." *Parking* March 2009.

Monahan, Dan. "Status of Automated Vehicle Storage Systems in the US." *Parking Today* January 2010.

Robotic Parking – Standard Guidelines.
www.robopark.com/guidelines.html

Automated and Mechanical Parking Association – Presentation.
www.ampapark.org/presentation

Parking Today Articles

Article Abstract from May, 2003

Automated Parking: Is It Right for You?

Gary Cudney

Automated parking made a splash in the United States a few years ago when the City of Hoboken, NJ, began constructing the first fully automated parking facility utilizing new computer technology. There had been some mechanical lift type structures built in the past but nothing in recent years using technology developed for automatic storage buildings or for automatic parking found in Europe or Southeast Asia. There are as many as 15 companies who claim they will produce automated parking facilities in the United States in recent advertisements in Parking Today and other parking magazine. Some of the manufacturers have united to form the Automated and Mechanical Parking Association.

You may have noticed that automated parking has been given much publicity by the parking magazines. Interestingly, the oldest article found in a search by the author was in the November/December 1996 edition of Parking Today and the second was in the September 1998 issue of the same magazine titled, "Automatic Garages Are on the Way." This article title begs the question: "What is taking so long for the automatic parking industry to 'take off' in the United States?"

One reason for this is that the Hoboken project was plagued with very public construction problems, and then became embroiled in contractual and legal issues. Though these problems are long past, it seems the Hoboken project gave the emerging industry enough negative publicity that a "wait and see" mentality resulted and this significantly delayed the development of the automated parking market. Other reasons include their higher construction cost compared to conventional parking lots or ramped structures (but this may be offset by the potential for lower land costs per space and the system manufacturers claim that operating and maintenance cost will be less than for a conventional ramped parking structure), self-park parking structures, concerns about breakdown, and uncertainty about operating and maintenance costs.

A boost

The industry should now get a boost from the opening of the 312-space Hoboken facility as well as the opening last July of a 74-space automated facility in Washington, DC, for an apartment building. The Washington, DC, project became the first of the new generation of automated facilities to open in the United States because of the delays in Hoboken.

Despite the slow start for the automatic parking industry in this country, it appears there is a market for them and that more will be built in the near future. Parking Today continues to promote the technology, and for three consecutive years gave special attention to it at the PIE Conference. The manufacturers continue to market their products and provide owners and developers with proposals for new automated parking facilities. Automated Parking is another means of satisfying the parking needs of a building, neighborhood, central business district, campus, airport, etc. That is why it is important for the parking

industry to understand this technology and consider it as a solution in situations where it makes sense.
I traveled to Europe in March 2002 to observe automated parking in operation. A very impressive facility that was visited is a 400-space automated parking project in Vigo, Spain, on the Atlantic coast just south of Portugal. This facility is owned by the city and serves the downtown retail district. The structure is underground, beneath a plaza deck adjacent to the bay and a marina.

Vigo, Spain

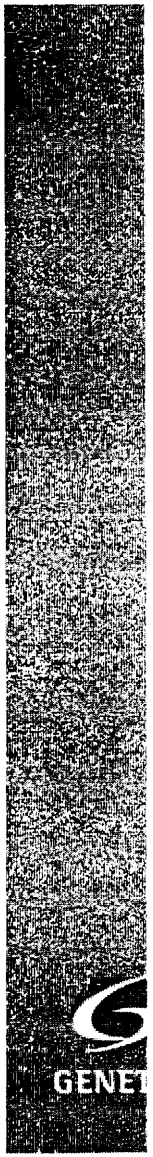
The Vigo automated parking facility is configured so that every parked vehicle is accessible by redundant equipment such as horizontal movement shuttles, vertical movement lifts and the transfer compartments. They even have redundant emergency generators. This level of redundancy assures that a breakdown of one piece of equipment will not shut down the retrieval of vehicles, but only slow the process down.
The facility has eight entry/exit compartments, four vehicle lifts and eight shuttles. The typical retrieval time is about two minutes. However, it took about four minutes for our vehicle to be retrieved as we waited while two inbound vehicles were moved by the lift before bringing our vehicle to the cabin. Nevertheless, four minutes is not objectionable when compared to the time it would take to walk to a vehicle and drive out of a conventional ramped parking structure.
The Vigo facility has operated continually without downtime for three years, so the European manufacturer is now recommending significant cost savings on new facilities by eliminating the redundant systems. John Broad of Broad AutoPark, the Detroit, MI-based representative of the manufacturer, says user concerns about equipment breakdown are best addressed not with redundant shuttles and lifts, but with regular preventative maintenance on a contract basis and the use of redundant electrical components and operating computers. They also configure the facility so that one lift serves about 100 spaces. If an individual lift required service, spaces served by other lifts would still be in operation. Further, the onsite stocking of adequate spare parts such as motors, gearboxes, sensors, limit switches, wheels, etc., will help eliminate downtime.

Ideal market

I toured the Hoboken facility in December of last year. Like the Vigo project, it is fully redundant. It was impressive that the desperate parking needs of the residential neighborhood could be met on a tiny 100-foot-square site that provides more than 300 spaces. The facility has four entry/exit compartments, two lifts and 14 shuttles on seven parking levels. Robotic Parking, the manufacturer, has received rave reviews from the users and the opening was even featured on CNN.
One ideal market for automatic parking seems to be smaller facilities between 80 and several hundred spaces on small land parcels not sufficient in size for an economical conventional parking structure. If the site is less than 100 feet wide and the length is less than 180 feet long, then automated parking may make sense. Ideally the facility would not have high peak hour entry and exit volumes and would have a very high percentage of repeat users (due to the confusion that comes when unfamiliar parkers first use this type of system).
One likely market is the conversion of existing buildings located in dense urban areas into residential units where other more traditional means of parking are not available due to the lack of land for parking lots or conventional ramped structures. Other uses for this technology include new residential developments, offices, airports, universities or hospitals that are landlocked; valet parking; doctor parking; and other monthly parking uses. Automatic facilities larger than a few hundred spaces are possible, but the entrance and exit capacity, queuing and vehicle retrieval times would need to be carefully studied.
Automated parking has many advantages, but it also has many disadvantages compared to conventional ramped parking structures, as shown in the chart nearby.

Advantages of Automated Parking Facilities

* Better perception of security because patrons do not walk to and from their space.
* Feasible for very small sites that cannot accommodate a conventional ramped parking structure.
* High parking efficiency (i.e. sf/space and cf/space).
* No driving while searching for an available space.
* Reduced emissions.
* Patrons wait for their car in a controlled environment.
* Less potential for vehicle vandalism.
* Minimal staff needed if used by familiar parkers.



* Retrieval time can be less than the combined driving/parking/walking time in conventional ramped parking structures.
* Easier facade integration without ramping floors or openings in exterior walls.

Potential Disadvantages of Automated Parking Facilities

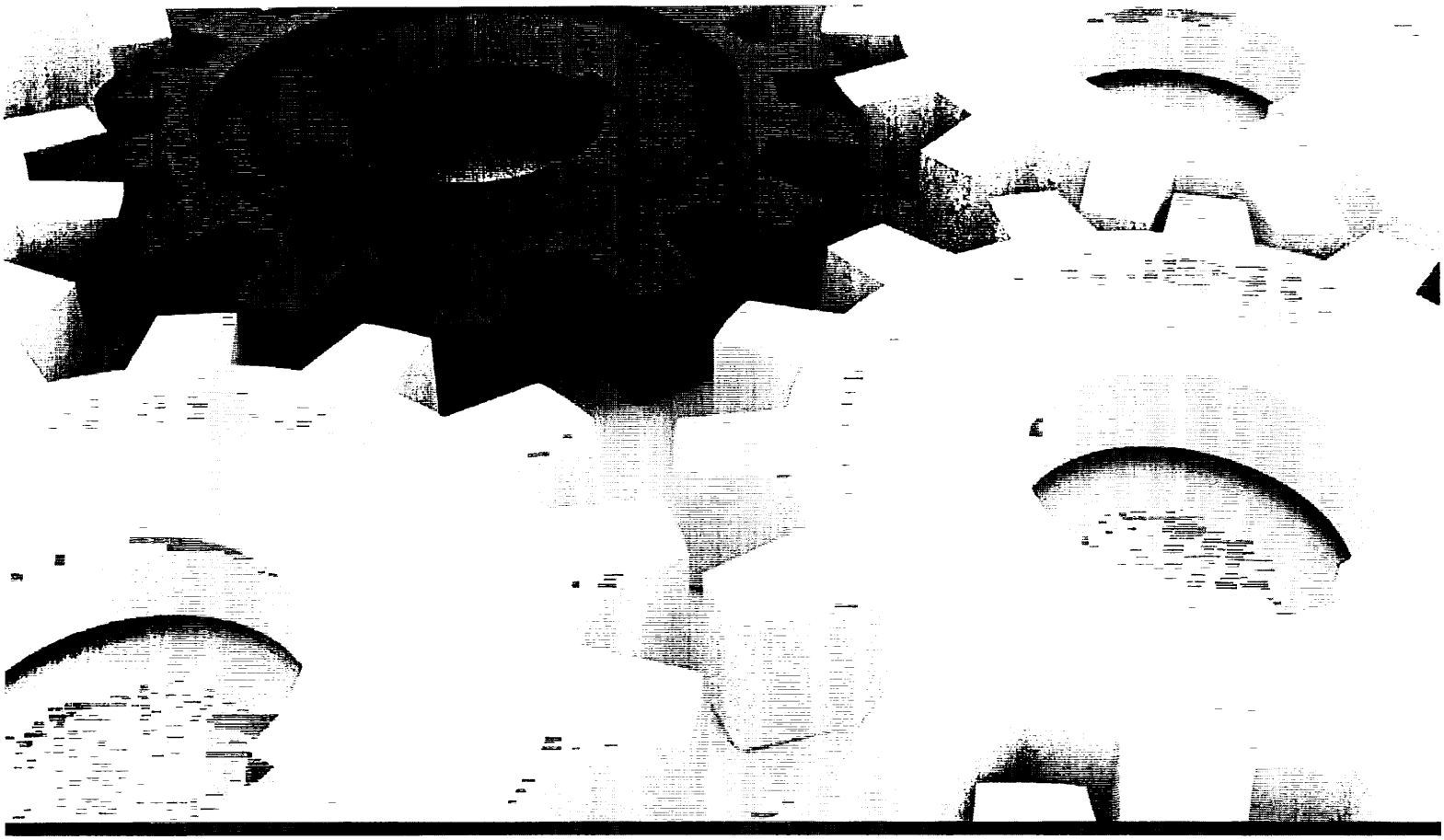
* Higher construction cost per space (but this may be offset by the potential for lower land costs per space and the system manufacturers claim that operating and maintenance cost will be less than for a conventional ramped parking structure).
* Redundant systems will result in a higher cost.
* Somewhat confusing for unfamiliar users.
* Not recommended for high peak hour volume facilities.
* Fear of breakdown (How do I get my car out?).
* Uncertain building department review and approval process.
* Necessitates a maintenance contract with the supplier.

So, is automated parking right for you? It depends. A qualified parking consultant can help compare your options and select the parking system that is best suited for your application.

Gary Cudney, P.E., is President of Carl Walker, Inc. He can be reached at gcudney@carlwalker.com

PARK
TODA
Subsc
to th
Magaz
for
FRE

Parking Today ©2009 All Rights Reserved



Past Hoboken:

Automated Parking Facilities Enter Hopeful New Era

By Charlie Munn

Hoboken.

That one word may have delayed the takeoff of an entire industry. As one of the first installations of a totally automated parking garage in the U.S., Hoboken's effort was closely watched by the parking world.

It didn't go well ... until now.

"I think our garage was probably the single biggest hindrance to the growth of the automated parking garage industry in this country," says John Corea, director of the Hoboken Parking Utility, of a saga that began nearly 10 years ago.

After years of controversy, politics, allegations and finger-pointing, the troubled project finally re-opened in January 2008. "It's been up and running for a full year now. It's been super-reliable," says Corea, who was monitoring the garage's performance on the Internet when contacted for comment. "We have a few issues now and then as you have with any mechanical system, but it's going so well we're getting ready to open it up to our transient base."

As Hoboken Goes, There Goes North America?

Despite a track record of success abroad and a long, illustrious history here at home, the automated parking facility (APF) has struggled for widespread acceptance here in North America. With the turnaround in Hoboken, that may be changing.

"Everyone loves it," says Stan Perelman of Jani Real Estate. "It's super efficient and we've had no problems." Perelman's firm was watching the Hoboken example and now he exclaims, "I can't believe we waited so long. We're looking now at doing a couple more just like this one."

Perelman's new working installation at "One York" in Tribeca, downtown Manhattan, was completed in October 2008. This 32-unit condominium building houses what the system's provider, Park Plus, Inc., calls the "first fully automated parking system in the USA that uses sophisticated pallet-less technology for vehicle transfer." Residents of One York can view the mechanized, software-controlled parking process through a viewing window at grade level.

North American developers like Perelman are finally catching on to the qualities that have helped APFs establish a strong niche market around the world. "Customer convenience and security are the biggest advantages," says Don Monahan, P.E., vice president for Walker Parking Consultants.

"It's analogous to automated valet parking," Monahan says. "Also the ability to achieve significant parking spaces in a small footprint. Many high-end condo projects are considering automated parking. On a condo project in Bellevue, Washington, 32 parking spaces were provided on four levels in a 32 by 60 foot area."

History Repeating Itself

The advantages of "stacking" type technologies have been evident since the birth of the parking industry in the early 20th century. "Mechanical" garages used elevators that, in those early days, were put into motion by pulleys and horses. Later, steel-framed "car stackers" were deployed to double or triple the number of cars that could be parked in the equivalent of one car space. These devices, while mechanically powered, still required human operators, however.

One of the first mechanical garages was developed in Paris, France, by Auguste Perret, according to author and practicing architect Shannon McDonald (See sidebar on page 26 on McDonald's recent book on the history of parking garages). Perret, like many in the parking industry was a true "Renaissance" man, noted for his skills as an architect, builder and civil engineer. McDonald notes that it was this unique confluence of talents that enable him to conceive, design and build his facility, the Garage Rue dePonthieu, in 1905. Imitators followed.

While Europeans may have invented the mechanical garage, the forerunner of today's automated parking facilities, "in the 1920's, innovation was simply phenomenal in the U.S.", McDonald says. "Some of the facilities were as high as 25 stories and a number are now adaptively re-used as apartments and condominiums and historically designated for their beautiful contribution to the urban fabric."

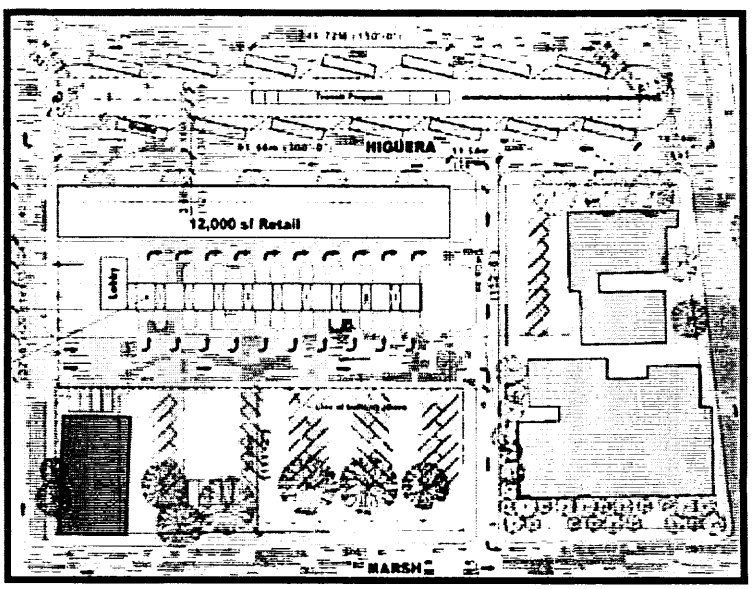
There was a resurgence in automated parking facilities in the 1950's, McDonald's research discovered. "There have been all kinds of horror stories but the truth is some of those automated garages from the 1950's are still in use today," McDonald states.

How They Work

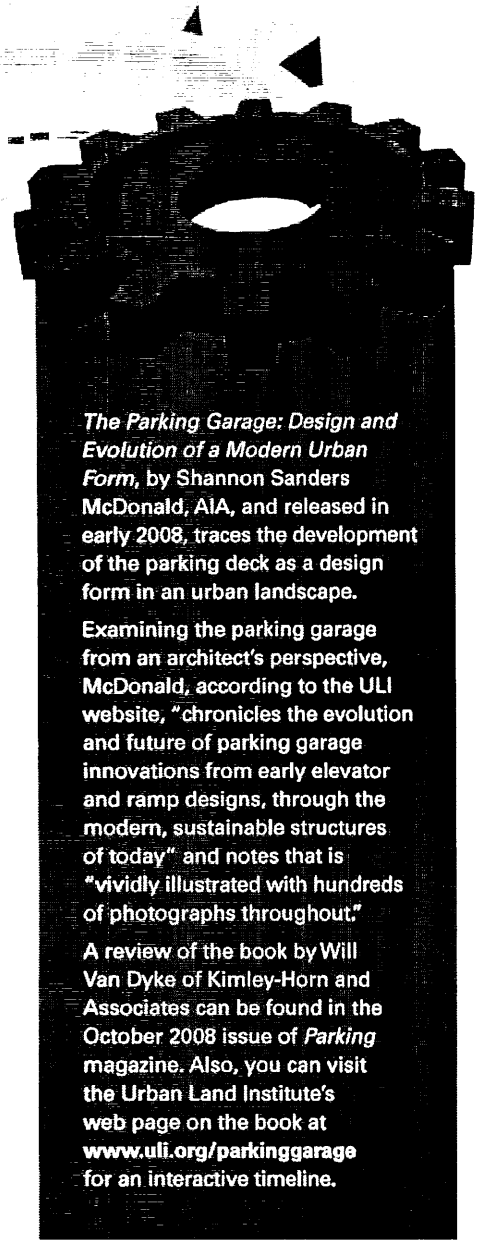
Automated, mechanical parking structures use computer-controlled vertical lifts and horizontal shuttles to transport vehicles from an arrival area to a remote compartment for storage without human assistance, explains Walker's Monahan, who also serves as chairman of the NPA's Automated Parking Facilities committee.

There are generally two types of designs, Monahan says. "One consists of horizontal shuttles at each level of parking with separate vertical lifts. The second system consists of a single transport device that moves horizontally on rails at the lowest level with the vertical lift mechanism within the same transport device. There are also pallet systems and non-pallet systems. Vehicles may be transported on a pallet or the transport device may pick up the vehicle by the wheels and deposit the vehicle on a rack in the storage space."

"The significant...difference between manufacturers is whether the system functions with a crane or elevator/lift," says Avner Barak, sales and marketing director for the Automated Parking Solutions System Division at Unitronics. Unitronics is credited by Hoboken's Corea as being the savior of the city's experiment with APFs, retrofitting its software and operating system into a previously constructed design.



Layout of large scale automated parking facility in San Luis Obispo, Calif. Note the facility features ten entry/exit points. Photo courtesy of Walker Parking Consultants.



The Parking Garage: Design and Evolution of a Modern Urban Form, by Shannon Sanders McDonald, AIA, and released in early 2008, traces the development of the parking deck as a design form in an urban landscape.

Examining the parking garage from an architect's perspective, McDonald, according to the ULI website, "chronicles the evolution and future of parking garage innovations from early elevator and ramp designs, through the modern, sustainable structures of today" and notes that is "vividly illustrated with hundreds of photographs throughout."

A review of the book by Will Van Dyke of Kimley-Horn and Associates can be found in the October 2008 issue of *Parking* magazine. Also, you can visit the Urban Land Institute's web page on the book at **www.uli.org/parkinggarage** for an interactive timeline.

Barak explains, "Typically, the smaller systems use cranes, while larger systems use lifts. Also relevant is whether the manufacturer can provide the fire and building and safety requirements to conform to governmental codes and restrictions. Significant differences in manufacturers design vary for throughput volume, average storage and retrieval time, design complexity, terrain and geometry constraints, advanced software and control techniques, and maintenance and manual intervention required."

Walker's Monahan points out that many manufacturers have experience in non-parking arenas and this base of business may help them ride out a slow acceptance period in North America. "Most manufacturers are divisions of larger steel conglomerates based overseas such as Westfalia, Wohr, Krupp, Stolzer Parkhaus, Klaus, etc., or automated parking is an extension of their main business such as Boomerang Systems (amusement rides) and LTW (Doppelmeyer ski lifts). The U.S. market is an extension of their overseas operation. Also, many of these firms also provide automated storage systems in warehouses such as Quad Graphics in Milwaukee (Westfalia). LTW provides automated storage of boats at marinas."

Likewise, publicly-traded Unitronics has dozens of working installations in the much more complex field of automated logistic systems (automated warehouses, distribution centers), from which it derived its ability to design, build and maintain automated parking systems. The firm has many projects in different phases of design or execution in the United States, Europe, Mexico and Israel.

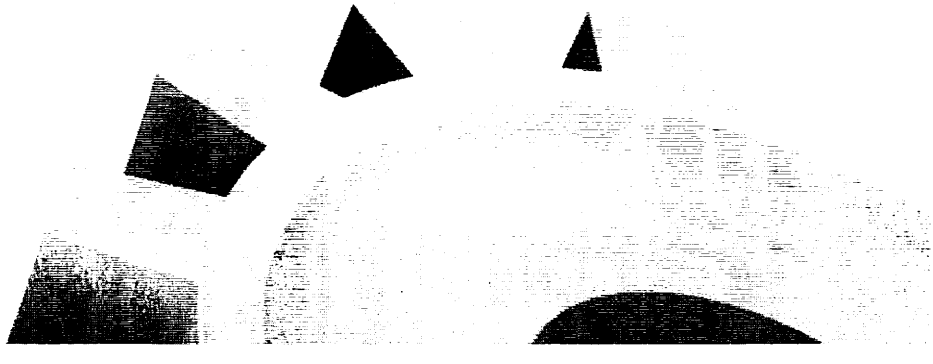
In business since 1968, Park Plus established itself as a market leader in mechanical parking stackers and related technologies. Since its acquisition by storage and retrieval specialists in 1996, Park Plus has pursued development opportunities in high-density vehicle storage systems.

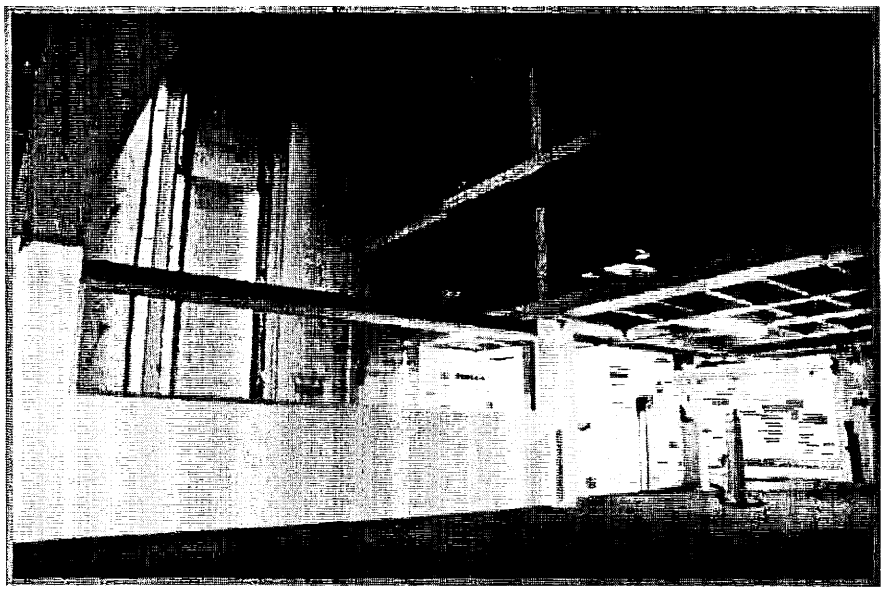
Why Not Here?

"America is very different from Europe and Asia," McDonald opines. "We do not need to build these structures because of limited availability of land; we typically have other options. For Americans it's usually more about land use choices." McDonald describes herself as "an advocate of finding the best architectural solutions for the location, site and program and developing more long-term sustainable choices for people, our living places and the environment."

"Automated parking facilities provide a potential solution to accommodating parking on constrained sites under the right circumstances. They are here to stay."

– Don Monahan, P.E., Walker Parking Consultants





The OneYork residential condominium in NewYork City features a totally automated parking garage. Photo courtesy of Ryan Astrup, Park Plus, Inc.

Ryan Astrup, associate architect at Park Plus, agrees, noting the demand for high-density parking systems in Europe and Asia has been more profound than in North America "due to space limitations, building restrictions and the pure need that has forced a traditional garage to become an efficient and more sustainable structure."

"Also," Astrup says, "Europe and Asia have been on the forefront of storage and retrieval technologies, and applications of these technologies have been accepted widely as a normal advancement in parking thinking."

Unitronic's Barak also offers up a commonly heard refrain. "The main concern we encounter is the fear from new technology," he says. "Technologies such as the cellular phone, the hybrid car, etc., have evolved faster in Europe and the Far East before flourishing in North America. Automated parking systems are not different in this aspect."

Considerations in Choosing a APF

In the opinion of some, another reason for slower acceptance of APF is the simple fact that it is a niche product that fulfills a specific need.

"They are most advantageous on sites that are too small to design and construct a ramp-access garage," says Monahan. "If your site is adequate for a ramp access garage, then do it. If you have limitations on height or depth in the ground, then automated garages may be the solution as they can accommodate the same amount of parking spaces in half the volume of a ramp-access garage."

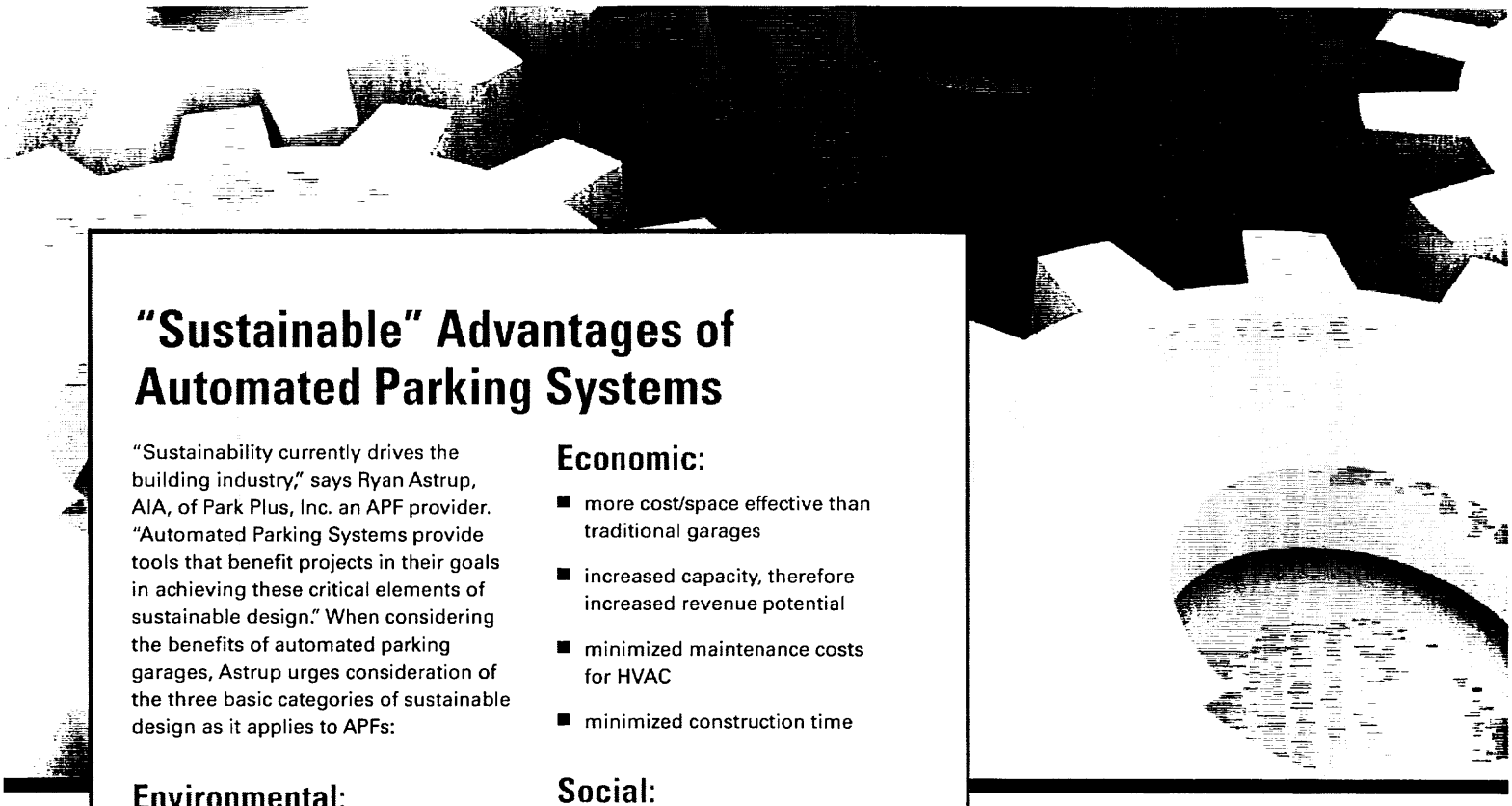
However, automated parking does not meet demands of crowd events like theaters and stadiums due to the high volume requirements during a peak time, Barak of Unitronics notes.

Monahan concurs with this assessment. "They are not well suited for large capacities or for uses that generate high peak hour volumes," he notes. "The number of entry/exit compartments required for large garages presents a challenge for access design at the street level. An 800-car downtown garage in San Luis Obispo required 10 entry/exit compartments. Accommodating the access roads in and out of the structure consumed extensive site area at the street level."

Number of Transport Devices is Key to Customer Satisfaction

Larger systems that are designed for use during peak periods usually have more than one set of devices to cater for multiple, simultaneous storage/retrieval cycles, says Park Plus' Astrup. "Entry/exit stations are also simply dual-directional, with the ability to serve as either... Additional vehicle shuttle devices will also provide the ability to handle multiple retrievals at the same time. Further, the software for the system can be programmed to allow earlier retrieval requests, and can place the vehicle in a storage area close to the exit station for faster retrieval."

Retrieval times will vary upon these factors. Hoboken's Corea says his facility experiences a range of two to



"Sustainable" Advantages of Automated Parking Systems

"Sustainability currently drives the building industry," says Ryan Astrup, AIA, of Park Plus, Inc. an APF provider. "Automated Parking Systems provide tools that benefit projects in their goals in achieving these critical elements of sustainable design." When considering the benefits of automated parking garages, Astrup urges consideration of the three basic categories of sustainable design as it applies to APFs:

Environmental:

- minimized spatial requirements: smaller building footprint
- efficient land-use application
- less building materials
- reduced or no ventilation required (no running vehicles in system)
- reduced or no lighting (only required for maintenance)
- energy efficient architecture
- no ramps, elevators or stairs required
- modular design allows custom fitting of garage for site constraints
- no running engines in garage

Economic:

- more cost/space effective than traditional garages
- increased capacity, therefore increased revenue potential
- minimized maintenance costs for HVAC
- minimized construction time

Social:

- localized collection stations (no need to "hunt" for parked vehicles)
- increased service aspect for vehicle delivery.
- safety: no dark, quiet and intimidating areas to walk through
- theft, vandalism or accidental damage eliminated (no people in storage area)
- parking operator can manage garage in real-time

five minutes on average, not much different from the time a parker would experience in retrieving his/her own vehicle in a self-park garage. This is within the norm, says Monahan.

"The industry standard is that the system should be designed for a maximum storage or retrieval time of two minutes from the farthest parking space," he says. "The number of lifts and transfer devices must be designed to achieve this criteria."

Monahan also notes the impact of "dwell time" in the service rate of the entry/exit compartment. "Dwell time is the time for patrons to collect their pets, children and belongings and vacate the entry/exit compartment... dwell time averages approximately 40 seconds. This must be added to the storage/retrieval time to determine the total time to store or retrieve a vehicle. Repeat users will have a shorter dwell time than unfamiliar users."

Construction and Cost

Most manufacturers of APFs say that the construction time averages 10 – 12 months. Other factors affect this, as Walker's Monahan reveals. "Because automated garages are generally much smaller on average than ramp access garages, the time is somewhat longer than a ramp access garage due to the time to manufacture the machinery," he says. "Oftentimes, the automated garage is in the basement of a much larger building. The shell of the building must be completed before the automated machinery can be installed. This factor could extend the completion time."

Manufacturers claim cost equivalence with concrete garages. "Unitronics' technology makes it possible to provide automated parking systems at similar or less cost per parking space than conventional parking," Avner Barak states, "Our client can choose between dramatically reducing the total volume of space required for parking spaces or double/triple or more the number of cars in the same space. This provides the option to add more income producing space for condos, offices, retail and other uses."

Monahan qualifies that point, stating, "The cost is a function of the size of the automated parking facility. A small facility (less than 100 spaces) will cost on the order of $30,000 to $40,000 per space as the machinery is amortized over a relatively small number of spaces. The cost of a large automated parking facility (300 stalls or more) could be as low as $20,000 per space."

Maintenance and Reliability

Most manufacturers, consultants and end users seem to agree that reliability of APFs is the same or better than that experienced for elevators. Therefore, preventive maintenance is vital to prevent breakdowns. Monahan's experience has been that many failures are the result of a dirty sensor that disables the ability to transfer a car into a space.

"This type of failure is quickly and easily fixed," he says. "Also, one can override the computer system to manually deliver a vehicle. However, this fix requires human intervention which defeats the purpose of the automated system."

Similar to passenger elevators, APFs require experienced technicians to carry out routine service and maintenance on all equipment to extend the durability of the system. Regular lubrication of parts, cable ware, cable extensions, and rollers mandate routine inspection.

Failures can be significant; therefore, manufacturers emphasize redundancy in their designs, with backup vehicle transport mechanisms. Astrup says back-up generators and battery back-up supply units can be incorporated to provide additional energy in the event of a power failure. Should the software of the Park Plus system experience a problem, trouble-shooting and reprogramming are instantaneous through a permanent Ethernet connection directly linked to the firm's central control center.

Monahan suggests that if a patron's vehicle cannot be retrieved, the manufacturer, as part of the operational contract, should provide an alternate means of transportation.

The Future of Automated Parking Facilities?

After a slow start, APFs may finally be catching on. "I estimate that there are over 50 automated parking projects contemplated at the current time," says Monahan. "In the next two to five years, there will be several new facilities constructed mostly for residential projects, rental car facilities, retail vehicle sales facilities or other uses with low turnover and low peak hour traffic."

Park Plus' Astrup feels there's a sea change due to a variety of factors. "Automated garages are presently changing the building industry's approach to conventional parking," he says, "offering economic, environmental and social benefits that far out way traditional approaches to resolving the needs of the garage."

Monahan points out rarely heard "good news" about APFs, like the 72-space automated garage at Summit Grand Parc in Washington, D.C. "It's completely automated with no on-site personnel," he says. "Maintenance is provided by Mid-America Elevator on an as-needed basis. There are very few service calls."

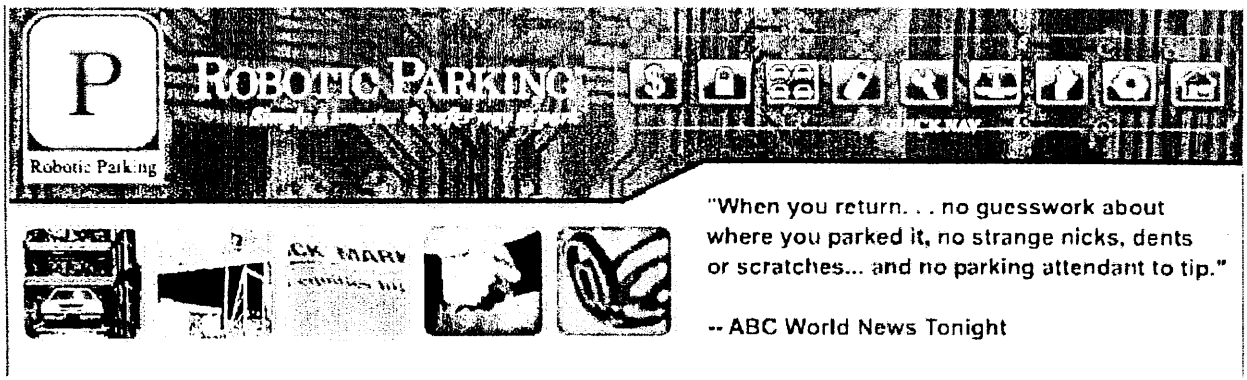
The industry also banded together several years ago to promote the use of APFs, forming the Automated and Mechanical Parking Association.

As success stories like Summit Grand Parc, One York, and Hoboken become showplaces for the APF industry, the parking world may begin to warm up to the concept and technology. In spite of his city's past experience, Hoboken's Corea enthusiastically reports the city is planning several more APFs. "I believe in this industry," he says unequivocally. ↖

Charles R. "Charlie" Munn III, CAPP, CPP, is a former parking consultant and commercial parking executive. He is now a human resources and customer service management consultant. Contact him at: **cmunn3@aol.com.**

"I believe in this industry."

– John Corea, Director, Hoboken Parking Utility



Guidelines

PRINT PAGE

STANDARD GUIDELINE FOR AUTOMATED PARKING FACILITIES in the UNITED STATES

This Standard-Guideline [SGL] will describe the design parameters, construction and operation of Mechanical Parking Systems [MPS] and Automated Parking Facilities [APF] in the US. MPS and APF may consist of simple devices that stack two or three vehicles on a single parking space and range to sophisticated fully automated facilities in which multiple robots perform the storage and retrieval of vehicles through computerized processes without human intervention. Sizes range from 2 spaces to several thousand parking spaces.

It is not the intention of this SGL to specify detailed structural, mechanical, electrical and electronic issues as these are well covered in reference codes mentioned below. Moreover this SGL intends to provide an overview of key features and implementations typically required by building codes as well as familiarize Authorities, owners, designers and the public with this type of parking system as to layout, typical dimensions, fire and life safety features, accessible design, vibration and sound attenuation, traffic and access design considerations. This SGL also addresses operational aspects for the operation of Automated Parking Facilities and their effect on public streets traffic, queuing and throughput capabilities.

REFERENCE CODES

ANSI	American National Standards Institute
BOCA	Building Officials & Code Administrators
ISO	International Standards Organization
NFPA	National Fire Protection Association
NEC	National Electric Code
ASA A113.1	Safety Code for Mechanized Parking Garage Equipment
ASTM	American Society of Testing Materials
ISA	International Society for Measurement & Control
ISO 9000	ISO 9000
OSHA	Occupation Safety & Health Administration
UL/ETL	Underwriters Laboratory
ADA	Americans with Disabilities Act Accessibility Guidelines
ASME B30.13	Storage Retrieval (S/R) Machines and Associated Equipment
NMC	National Mechanical Code

Table of Contents

1 Nomenclature
2 Mechanical and Automated Parking
3 Use of the garages, size and infrastructure needed
4 Requirements on slot sizes
5 Automated Parking Facilities
5.1 Location, Size and components of Terminals
5.2 Function of Terminals and Public Areas
5.3 Throughput Capability
5.4 Traffic Effects and Queuing
5.5 ADA requirements
5.6 Fire Safety
5.7 Sound Emissions - Vibrations
5.8 Zoning / Codes for M/A systems
5.9 Graphical User Interface
5.10 Ventilation / Heating / Air Conditioning
5.11 Lighting/ Accessibility for Maintenance
5.12 Diagnostics
5.13 Maintenance / Operator
5.14 Spare Parts Package

---

1 NOMENCLATURE (Definition of the Terminology used in this SGL)

Automated Parking: All the steps necessary to initiate, perform and control the process of vehicle storage or retrieval utilizing a multiple of machines with vertical and horizontal transport capability operated via software commands to the different machines. No human intervention needed.

APF : Automated Parking Facility

AVI : Automated Vehicle Identification; A transponder mounted at the vehicle entry automatically identifies and accepts vehicles with properly issued identification tag access to the facility.

Carriers : A certain type of apparatus in a M/A system performing horizontal movements in x directions

Controls : The part of a system which is comprised of computers, sensors, PLC's; in short the entire electronics

Credit Card Access: A patron accesses the parking facility by inserting a credit card into the entry reader, which provides for automatic payment of the parking fee allow patrons to use the M/A system via the use of a regular credit card

DTO : Dynamic Traffic Operation

DVO : Dynamic Valet Operation

DwellTime : The time it takes a Patron to drive into the Terminal and walk out to the point of system activation

HMI : Human Machine Interface, another word newer date for GUI or MMI (Man Machine Interface)

Lifts : Transport devices used for vertical movement of vehicles (not to confuse with elevators)

Lobby : The designated area in an M/A system where patrons go to request their car for retrieval

Machinery : Another word for lifts, shuttles and carriers is not one single apparatus as there are specific words

M / A : Mechanical / automated

Mechanical System: Method of parking cars that involves a person to some degree (garage attendant or driver of car) to take necessary steps to initiate/perform mechanical movements, using different machines, which are

typically triggered by electrical pushbuttons, not a software program.

Pallets : A platform on which the car is transported and stored.

Patrons : Persons driving a car and using the M/A System for parking their vehicle

PLC : Programmable Logic Controller; an industrial computer performing tasks written on the so called inherent Ladderlogic (a software program written like a ladder, line by line in sequence following logical commands)

POF : Pay On Foot; A device which allows automatic cash or credit card payments of the parking fee and interfaces with the M/A parking system to store and retrieve vehicles.

Rack : The supporting frame for a M/A parking system, providing the necessary framework for storage, machinery and eventually the building around the M/A parking system.

Rail : fixed runway for a single or multiple machines in a M/A system

Retrieval time: The time measured from the moment of the activation of the retrieval process by the patron until the patron can access its car to drive out of the M/A system

RF : Radio Frequency; a means of communicating signals without wires but airwaves on certain frequencies

RF Tag : A card similar to the size of a credit card which transmits a defined signal to a reader which in turn communicates this signal to the main computer of the M/A system

Shuttle : A vehicle transport device that moves horizontally in x and y direction.

Slot : A storage space for one car inside a M/A system

Spaces : The amount of parking slots a M/A system can hold / park for a certain configuration of the system

Storage time : The time measured from the moment a patron activates the system to store its car after proper positioning of the car in the Terminal until a next patron can use one free terminal to enter with its car for another store

System : The entirety of the M/A facility including structure, mechanics, electric, electronic and software with hardware

Terminal : The drop-off and pick-up point of a M/A system

Throughput : The amount of cars in any one way flow, which the system can perform in a specified time frame

Ticketing Station: A form of access to the M/A system which dispenses a ticket to the patron. Located at the left outside of the outer door of the Terminal

2 Mechanical and Automated Parking

2.1 Mechanical Parking

By definition, mechanical devices perform a predetermined specific physical work without human intervention. By the push of a button or switch a single step movement is initiated to store or retrieve a vehicle. Examples: double or triple stacker, carousels, any set-up of fixed mechanical movements initiated directly by humans.

Typically mechanical systems serve for the storage of 2 to 30 cars per unit.

2.2 Automated Parking

Automated Garages are also based on mechanical devices, but they differ in so far that a) multiple mechanical devices are present and can operate simultaneously to store and retrieve vehicles in a multiple rack structure vertically and horizontally, and b) the operation is not directly initiated by human intervention, but by a software program specifically written for this system that controls the movement of all transport devices. Its management software tracks the location of the vehicles stored in the facility and returns the vehicles, requested from the patron upon initiation of the access system installed. Automated Parking Systems are designed to receive one input from the patrons for the storage or retrieval of the vehicle. It initiates and controls all necessary commands and steps in proper sequence by software commanding the devices to store or retrieve the car. This system is most often characterized as automated valet parking.

Automated parking facilities are geared to store and retrieve in a fully automated way 50 to several thousands of cars.

3 Use of the garages, sizes, infrastructure

Mechanical Systems are best suited for capacities of 2 to up to 40 cars per unit, and are suited for any type of land use.

Automated Parking facilities are best suited for larger developments consisting of residential, office, hotel, entertainment, shopping, airport, hospital and university campus projects, preferably with parking requirements ranging from 50 cars to several thousand. Automated Parking Facilities are particularly suited to small sites where typical ramp-access, self –park garages physically cannot work.*

Automated garages can be designed to achieve a throughput of several hundred cars per hour. Depending on the configuration of the devices and the Terminals the throughput will be determined. The manufacturer of the system determines the throughput per Terminal. the number er Terminal and devices inside the facility can then be sized to accommodate the rate of flow of trafic entering and exiting the facility.

Both these systems provide the possibility to park a multiple of cars on the footprint of one car slot using underground or above ground height. Entrances to the Facilities can be generated at random heigts.

*A ramp-access garage has a typical stall width of 8'6" to 9'0" and a typical floor height of 10 feet. The typical ramp slope used for vertical circulation and parking is 5 to 6%. Therefore, a minimum ramp length of approximately 180 to 200 feet is required for vertical circulation in a multi-story facility. This length may be divided into two parking modules that are each 60-feet wide. Therefore, the minimum size lot for a ramp-access garage is approximately 120 feet by 180 feet. This size lot is often not available in dense urban areas.

Even on larger sites, the smaller stalls and lower rack height that are possible with mechanical garages result in double the amount of parking spaces within the same volume as a typical ramp-access garage. Because mechanical parking stalls do not require additional clearance for door opening, pedestrian headroom, and turning maneuverability into a stall, they may be sized tightly to the size of the vehicle (i.e. approximately 7 feet wide by 5 feet high). The resulting lower rack heights facilitate development of parking on sites where there are height limitations above grade or a high water table or other subsurface problems in below-grade applications that prevent deeper construction. The narrower stalls also result in more spaces on any level in the garage.

4 Requirements on Slot Sizes

The minimum size / capacity of all the storage spaces and the machinery in a M/A System for standard passenger automobiles shall be 7 feet wide by 19 feet long with a minimum clear height of 5 feet. The dimensions required to accomodate vans, light trucks and sports utility vehicles shall be higher (approximate clear height of 7 feet), but not wider nor longer.

The machinery shall be capable of handling a minimum weight of 4,500 lbs per vehicle for standard passenger automobiles.

Appropriate measures must be provided to deny access to cars exceeding the capacity of the system. Also, portions of the parking facility can be designed to accommodate over-height vehicles while the majority of the spaces are dimensioned for standard vehicles or compact vhicles.

ADA requirements shall be incorporated in all M/A Systems at the Terminal or Terminals.

5 AUTOMATED PARKING FACILITIES

5.1 TERMINALS: Location, size and components

The Terminals are the most important interface zone between patrons and the Automated System. Therefore this area requires special attention.

Since cars drive into the Terminal(s) and out of it each time they use the garage, the preferred location of the Terminal(s) and of the driveways serving it is near the center of the structure on the perimeter. The preferred elevation of the Terminal(s) is that of the incoming road system.

The Terminal must be sized to allow patrons to safely and comfortably drive in and out and load / unload the cars. Turning radii and width of drive aisles shall be designed according to the respective needs with a minimum inside turning radius of 16' and an outside radius of 28 feet. The minimum clear width of the Terminal shall be 15 feet, thus leaving 3 ½ feet left and right of the car for passengers to leave / enter the car. The Terminal access opening shall have a clear width of 15 feet for a vehicle turning directly into the Terminal. If a straight approach to the Terminal is provided for at least 30 feet in advance of the Terminal, then the width of the access opening may be reduced to 12 feet.

The length of the Terminal shall be more than19 feet.

The unobstructed height inside the Terminal shall be equals to or greater than 7 feet.

The Terminal shall be equipped with sensors to ensure the right positioning of the vehicle to be transported as well as determine the presence of oversized vehicles, protruding mirrors or racks, which exceed the size limitations of the system. Motion detectors and CCTV cameras or similar devices shall be installed inside the Terminal to ensure that no person or animals are inside the Terminal or the car when the machine starts moving.

The Terminal entrance doors shall be mounted, secured and operated safely, isolating the passengers from the Terminal during movement of the machinery and vehicles. Safety locks / emergency switches shall be installed to stop any machinery if a person or animal is detected in this area.

Cameras shall be installed to record digital photos of the physical condition of the car entering and exiting the premises. The images are also helpful to locate cars for patrons with a lost ticket and to validate damage claims by patrons.

Recesses in the floor area shall be minimized to the need of guiding the patrons in the "drive-in" process. All other areas shall be flat for pedestrian traffic. Gaps between moving parts and platforms need to be limited to ½ inch width. (compare with subways)

All M/A Systems shall comply with ADA requirements.

5.2 Function of Terminal and Public Areas

The Terminal is the exchange point between patron and machine and therefore special attention shall be paid to

the smooth functioning of this exchange center.

The driveways for inbound and outbound traffic shall be designed to provide sufficient queuing spaces (see more on section 8); simple visual signage and guidance shall clearly direct approaching traffic off the street and into the terminals. Respective commands via a visual message center shall be applied inside the Terminals for the patrons in such manner that an easy use of the system is possible.

Inbound / outbound traffic crossing shall be prevented.

Inside and outside Terminal doors shall be provided to prevent patrons and animals from coming into contact with any moving elements of the system. The doors shall be of closed material and withstand high usage with a daily duty cycle of at least one full turnover of the garage for 50 % of the amount of Terminals.

As Terminals are the exchange station of the garage, special attention shall be directed to ease the "drive-in" and positioning of the car by the patrons (preferably by means of physical aids);

Means for catching of debris and drippings from the incoming cars shall be applied to avoid such drippings to cars and machinery inside the terminals, during transportation and storage inside the system.

The Ticketing Station or access system shall be located outside the Terminal on the left side of the inbound traffic.

If the system has installed a radio frequency access system, the readers shall have enough range to detect approaching vehicles from at least 30 feet outside of the Terminal.

The Automated Facility shall be equipped with sufficient lobby space to hold the expected peak accumulation of patrons waiting for retrieval of their cars. the pay stations or other access readers shall also be located inside the Lobby. Also sufficient electronic message centers shall be provided to guide the patrons to the respective location to meet their car.

In case toilets are not available in the near vicinity of the Lobby, such shall be provided in sufficient quantity to accommodate the patrons needs close to the Lobby.

The operator room shall be located near the lobby to enable the operator to assist patrons and to oversee the operation of the garage.

All areas accessible for the public in an M / A System shall be illuminated with 40 Footcandle at a height of 3 feet above finished floor.

The Terminal area further shall comply with federal and local regulations.

5.3 Throughput Capability

The throughput of a system is the minimum number of cars a system can store or retrieve (measured in any random one way traffic), in the timeframe of one hour. However it must be taken into consideration that the patrons drive their car into or from the Terminals. A reasonable average dwell time of 30 seconds per car driving into the Terminal can be assumed if physical drive-in guidance is provided. In the absence of such physical guidance system, an average dwell time of 60 seconds shall be considered.

5.4 Traffic Effects and Queuing

For the implementation of a Mechanical/Automated System with more than 30 cars capacity, a traffic study shall be required to give the system manufacturer the opportunity to address queuing issues for that particular installation. For queuing calculations, a 15 min period of peak traffic shall be compared to the capability of the system to handle vehicles during that peak period. The result will indicate the number of Terminals required and the length of vehicle

queue resulting – if any- and required at each Terminal.

5.5 ADA requirements

As the only exchange point in a Mechanical/Automated System are the Terminals, only the access in and out of this area needs to meet the requirements of the Americans with Disabilities Act Accessibility Guidelines in addition to the other public and employee areas of the facility. These requirements include the ability to accommodate overheight vehicles (8'2"clear) as well as a minimum 36" clear accessible route in and out of the Terminal. Alternatively a sufficient number of ADA compliant spaces can be provided outside of the Mechanical / Automated System.

5.6 Fire Safety

The general scope of a Building Code is, to "control all matters concerning the construction, alteration, addition, repair, removal, demolition, location, occupancy, and maintenance of all buildings and structures, and shall apply to existing or proposed buildings and structures."

The intend of the Code is "To insure public safety, health and welfare insofar as they are affected by building construction, through structural strength, adequate means of egress facilities, sanitary equipment, light and ventilation, and fire safety; and in general, to secure safety to life and property from all hazards incidents to the design, erection, repair, removal, demolition or occupancy of buildings, structures or premises."

"The provisions of the Code apply to all matters affecting or relating to structures ....and their construction, alteration, repair, addition, and removal"

Classification of an Automated Parking Facility (APF) from a classical use and occupancy viewpoint (Public Garage) would fall into 'Use Group S-2, Low Hazard, Storage'. However, the viewpoint of a Conventional Public Garage does not apply for an APF.

The existing BOCA Code and its Commentary provides the following explanatory information regarding other Use Groups: (IBC 2000 and 2002 Supplement are derived and very similar to the 1996

BOCA in this regard)

"Buildings and structures of an accessory character and miscellaneous structures not classified in any specific use group shall be constructed, equipped and maintained to conform to the requirements of the code commensurate with the fire and life hazard incidental to their occupancy. Use Group U shall include....., tanks, cooling towers, retaining walls and buildings such as private garages, carports, sheds and agricultural buildings"

"Structures that are classified in the Use Group U, utility and miscellaneous use group, are typically accessory to another building or structure and are not more appropriately classified in another use group. .....They are not usually considered to be habitable or occupiable. Nevertheless many code provisions do apply and need to be enforced (e.g., structural loading foundations and material performance). Structures classified in Use group U are not specifically regulated by Table 503 for heights and areas because they are typically small, stand-alone structures having negligible fuel loads. Local zoning laws or ordinances will typically regulate the size of such utility structures." Further, if sections 507.1 are conformed to and NFPA 231C as listed in Chapter 35 are implemented, the "one story" facility according to use group S2 (and type 2c [IIb] construction) does not need to meet height and area limitations. (compare section 507.1 and exception 3 BOCA 1996) Further explanations see chapter 5.8 in this guideline)

Based on the results of our fire risk analysis, the following conclusions can be made:

- The probability of a fire in an APF is low
- Fires will usually be confined to the vehicle in which they originate. Fire spread from car to car is rare.

- Explosion or rupture of fuel tanks as a result of a car fire is unlikely
- Sprinkler systems are not likely to extinguish a car fire within an APF. Sprinkler systems will limit to a degree the burning of tires, exterior paint, and plastic body parts.
- Property damage from car fires in garages is generally limited to the car of origin and loss of life and injuries are not expected, as the APF is not occupied.
- Provisions shall be implemented in an APF that leakage of gasoline tanks or other flammable fluids are collected during transportation and storage of the vehicle.
- The automated storage equipment and the building / structure that will house the equipment (the building / structure) shall be considered separately. The equipment shall not contribute to satisfying any of the structural requirements of the building / structure.
- Construct the APF building / structure and the equipment with non-combustible construction without a specified fire resistance. In addition, those portions of the facility used for the transport and / or storage shall have a finish of non-absorbent, noncombustible material. Where the APF is located below a building, a 2-hour fire resistance rated separation shall be provided between the APF and the adjacent space use.
- As the nature of an APF provides the means to transport a vehicle without human interference, provisions shall be provided to detect a vehicle on fire and to transport it to a fire extinguishing cell at a space on ground-floor, easy accessible for firefighters.

5.7 Sound Emissions / Vibrations

As machines are moving weights of 10 to 20 Kips, certain noise emissions are to be expected as long as the structure is the supporting element for the machinery and the building. The manufacturer knows the dBa value and needs to ensure that the surrounding walls cover any sound emission of more than 40 dBa emanating outside the building, measured at the property line.

Should the garage be part of a mixed-use complex, not only sound but also vibrations resulting from the machinery need to be considered for potential negative impact to the rest of the building. Separating the foundation and supporting members are the best means to keep the influence to a very minimum.

5.8 Zoning / Building Code Considerations

Zoning aspects

Mechanical /Automated Systems do not need a special code or zoning or ordinance, as all building and construction related aspects are covered by existing building codes for low hazard storage facilities. Adjustments may be made in regards of zoning requirements for slot sizes, drive aisles, ramps, turning radii and inside heights as these requirements can be reduced for Mechanical / Automated Systems. Miami Dade County in Florida made such an adjustment with the following wording, which is recommended:

START QUOTE:
"....effective immediately, off- street parking spaces including tandem parking spaces that are provided by an automated parking garage system (robotic parking garage) shall not be subject to the minimum parking size requirements nor the parking stall and aisle dimensions provided in Article VII (off-street parking) of the Miami-Dade County Zoning Code. Automated parking systems must comply with Article VII in all other respects. In an automated parking garage, the robotic parking system mechanically parks and retrieves vehicles in a multilevel parking garage structure. The driver of the vehicle is not permitted to enter the automated parking garage vehicle storage area.

Automated parking garage systems shall be permitted in zoning districts where parking garages are permissible as a principal or ancillary use, subject to compliance with the regulations of the applicable zoning district, resolution, or covenant running with the land. The establishment of automated parking garages in other zoning districts where parking garages are not allowed as a matter of right shall continue to require approval at a zoning public hearing.

Non mechanized off-street parking spaces must comply with the provisions of Article VII."
END QUOTE

Some jurisdictions have already adopted automated warehouses, storage / retrieval and such may be applicable for Mechanical / Automated Systems as well. Regarding zoning aspects, and APF can be considered as applicable for parking- and storage regulated areas as well.

Building Code issues

The Nation's first fully automated parking facility was permitted by the Construction Official and Sub Code Official, under the 1996 BOCA code with the following classifications:

The upcoming IBC 2000 with its 2002 supplement is very similar if not identical in this regard of permitting of an APF.

- Use Group S2 , low hazardous according to section 311.3
- Type 2c construction, noncombustible according to table 503
- Section 504 allows building height modifications if an automated sprinkler system is installed in accordance with section 906.2.1
- Section 507 indicates "unlimited areas" for one story buildings – amongst others – in use group S2, if section 507.2 is adhered to.
- Exception Nr. 3 of section 507.1 regulates that buildings and structures of Types 1 and 2 construction for rack storage facilities, which do not have access by the public shall not be limited in height provided that such buildings conform to the requirements of section 507.1 and NFPA 231C listed in Chapter 35.

With these classifications, the APF was permitted and constructed accordingly and given the CO by the construction officials. The entire system is equipped with an automatic dry sprinkler system and respectively rated exterior walls.

5.9 Graphical User Interface / ON-Line Support

Automated Parking Facilities shall be furnished with a Graphical User Interface (GUI), or HMI, Human Machine Interface. This interface shall be positioned in the control-room. The GUI shall show the geometry of the entire System with occupancy and all installed machines moving in real time. The GUI shall be capable of running fully automated without human assistance, it shall have manual and maintenance mode and the capability of System Diagnostic of all critical mechanical, electrical and electronic equipment.

The parking facility shall have an installed and all time workable dial-in capability to the manufacturer / technical operator with a short response time to handle any alarms generated by the system.

5.10 Ventilation / Heating / Air Conditioning

Areas accessible to the public / patrons shall be equipped with sufficient heating, air conditioning and ventilation.

The storage area of the System in which no patrons enter but only maintenance crews, may be unheated and unconditioned space although some ventilation of outside air is recommended. No ventilation of vehicle emissions is required inside the storage area. Depending on the design of the Terminal, a ventilation of emissions may be

required in that area.

In case a natural air ventilation is designed for the storage area, the air turnover ratio shall be 1.0 the volume of the entire storage volume for a 12 hour period.

5.11 Lighting / Accessibility for Maintenance

Lighting in areas accessible to the public / patrons shall be illuminated to a minimum of 25 Footcandles measured at 3 feet above walking surfaces.

The storage areas of the System shall be illuminated to a minimum of 1 footcandle primarily for maintenance access. Portable task lighting outlets shall be provided for enhanced lighting for repairs, diagnostics and maintenance.

The system shall be designed such, that maintenance personnel has access to all storage spaces, machinery and electrical and electronic components in a safe manner. The usage of harnesses is acceptable as long as OSHA criteria are followed.

5.12 Diagnostics

Automated Systems may include a Graphical User Interface (GUI), or Human Machine Interface (HMI). These devices are computer models of the layout of the garage illustrating the movement of the various transport devices within the system and are designed into the software and displayed on the computer screen. This interface shall be positioned in the control-room. The GUI shall show the geometry of the entire System with actual occupancy and all installed machines reflecting real time movements / positions of machinery and stored vehicles.

The GUI, based on the source code shall be capable of running fully automated without human assistance; it shall have manual mode and maintenance mode operations and the capability of System Diagnostic of all critical mechanical, electrical and electronic equipment components.

The parking facility may have an installed and real time, on-line connection to the manufacturer / technical operator which allows for resolution of most errors remotely with a short response time in reaction to any trouble alarms generated by the system.

The system shall be capable of reporting alarms in different classes according to their severity for the System functionality. It shall report the need of component checks for proper performance of the different components. Preferably, a hotline support line shall be implemented to enable a remote system support.

5.13 Maintenance / Operator

In order to ensure the operational safety, planners, manufacturers and owners shall coordinate and implement suitable measures in order to avoid System interruptions as much as possible and to remedy such interruptions in a reasonable time.

A preventative maintenance schedule shall be in place covering all critical system components to be maintained for proper functionality. The regular scheduled maintenance of the System by qualified personnel; as well as on-site

spare parts are indispensable measures.

In case of public use of the APF, trained personnel must be available at short notice. The manufacturer undertakes to provide a trained technician for the prevention and remedy of interruptions during the main hours of operation of the APF. To cover the remaining hours of operation, the manufacturer shall train owner's on-site personnel as "system officer" to the degree, that these "officers" are capable of retrieving a car in semi automatic mode of operation.

APF's that do not serve public users may be staffed with "system officers" only.

The System diagnostics as mentioned above shall report to the on-site technical operator about necessary maintenance performance or component checks in advance.

The storage areas of the System shall be illuminated to a minimum of 1 footcandle primarily for maintenance access. Portable task lighting outlets shall be provided for enhanced lighting for repairs, diagnostics and maintenance.

The system shall be designed such, that maintenance personnel has access to all storage spaces, machinery and electrical and electronic components in a safe manner. The usage of harnesses is acceptable as long as respective safety regulations are followed.

5.14 Spare Parts Package

Enough spare parts shall be stored at the facility to ensure an immediate availability of exchange components in any case of a component failure.

In order to ensure needed repairs to be performed in a timely manner, the manufacturer and owner shall agree for a respective maintenance contract, covering the operating times of the Facility including a sufficient on-site spare parts package. A response time for System generated alarms of 30 minutes or less is recommended.

THE DRIVING FORCE IN CREATIVE PARKING SOLUTIONS

WALKER
PARKING CONSULTANTS

Silicon Valley Leadership Group
Smart Parking Conference Session A2:

Automated Parking Facilities

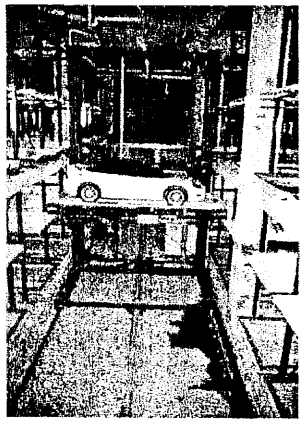
by
Don Monahan
March 8, 2006

Presentation Outline

- Description of automated parking operation
- Types of automated parking systems
  - Rack vs Pallet Systems
  - Trans-lift vs Separate Lifts/Shuttles
- Advantages/Disadvantages of Automated Parking Systems
- Example Projects
- Schematic Design Approach
- Design Example
- Summary

Overview

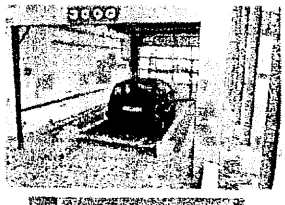
Automated, mechanical parking structures utilize computer-controlled, motorized vertical lifts and horizontal shuttles to transport vehicles from the arrival level to a remote compartment for storage without human assistance. Analogous to automated valet parking.

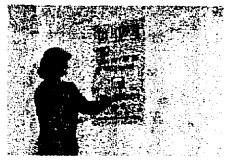


Summit Grand Parc, Washington, DC
60' X 100', Four Levels, 74 spaces
$20,000 per space

Storage Operation

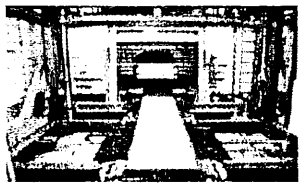
- Drive into transfer compartment. Vehicle is guided into place by steel rails or channels similar to an automatic car wash.
- Turn off vehicle, set the brake, gather belongings, pets, children, etc and clear the compartment.
- Activate the storage process by swiping a coded card or taking a coded ticket at parking kiosk outside the entry compartment.

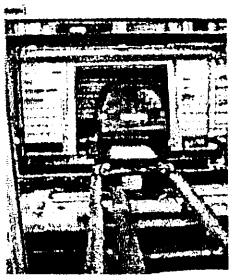




Storage Operation (continued)

Upon activation of the storage system, sensors measure the vehicle for compatibility with the design of the system, the doors close, and the vehicle is removed by machines from the entry compartment to a location in the storage vault. The storage location is recorded in the system for that ticket or key card.





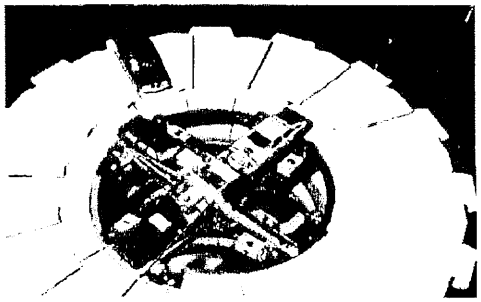
Retrieval Operation

Patron returns to customer lobby and swipes ticket or key card at pay-on-foot parking equipment and pays fee, if required.

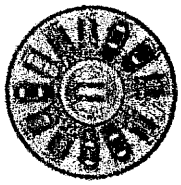
This process activates retrieval of vehicle. Computer determines vehicle location from entry transaction record for that user in system. Transport device is dispatched to storage location and vehicle is delivered to exit compartment. Electronic message boards in lobby direct patron to the compartment that vehicle is delivered. Patron drives out of exit compartment.

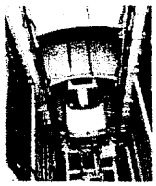
Automated Parking Silos

Grando - Japan



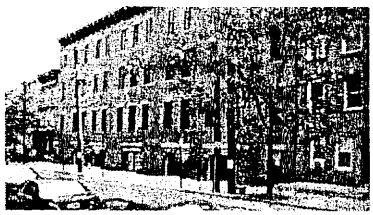
Trevi-Park - Italy

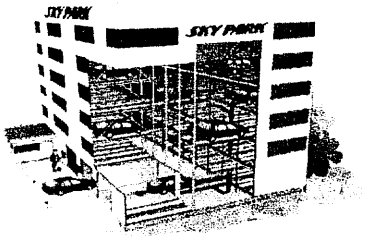




Hi-Rise Stackers/Automated Parking

Rectangular Systems



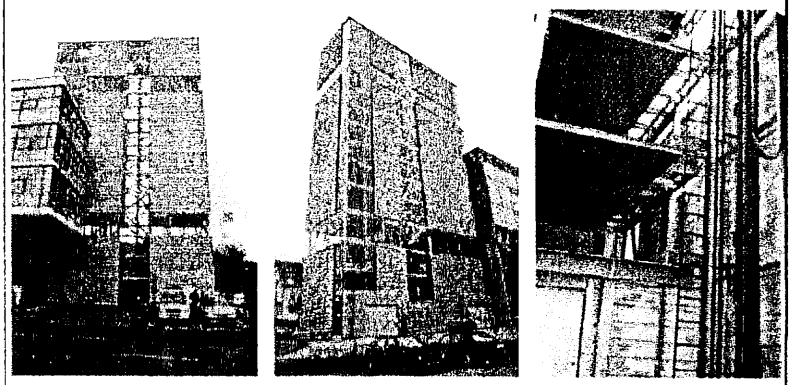


VENDORS:

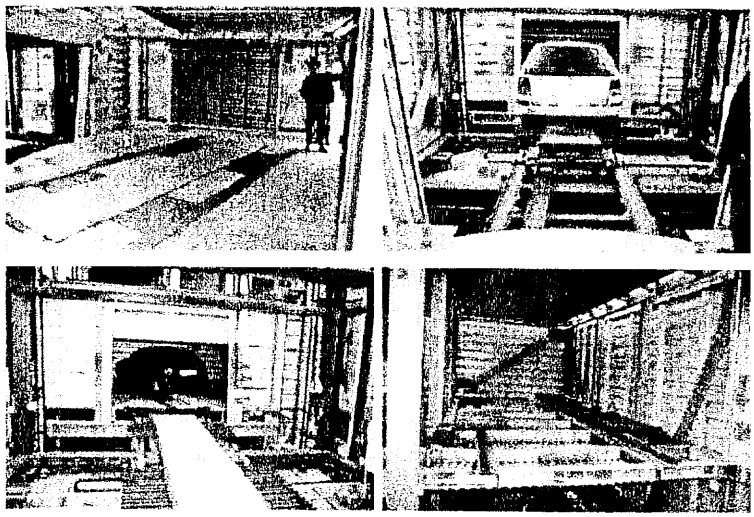
Robotic Parking
www.roboticparking.com

- Advanced Parking Technologies
  www.aptparking.com
- Westfalia Technologies, Inc
  www.westfaliausa.com
- Metro Parking Systems
  www.mp-parking.com
- SpaceSaver Parking Co.
  www.spacesaverparking.com
- Wohr Parking Systems
  www.wohr-parking.co.uk
- Klaus Multiparking
  www.klaus-autopark.de
- Park Plus, Inc.
  www.parkplus.co.za

Rack vs. Pallet Systems

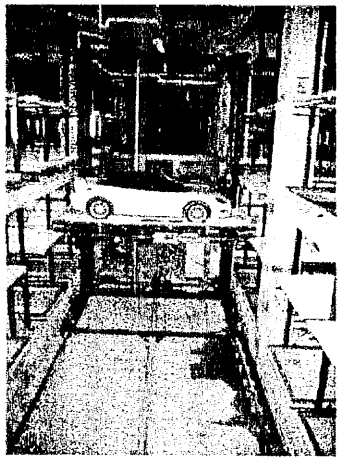


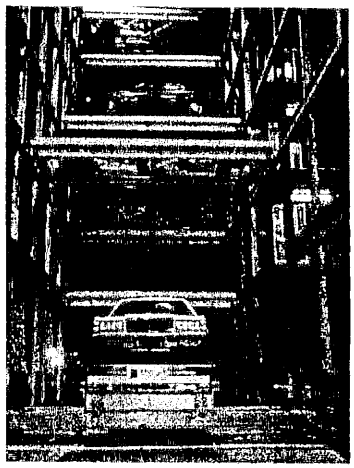
Rack System



Pallet System

Trans-lift vs. Separate Lifts/Shuttles





Advantages of Automated Parking

- *No Mechanical Ventilation* - Since vehicles are transported without the engine running, automated parking facilities do not require mechanical ventilation of vehicle emissions.
- *No HVAC* - The unoccupied storage vault does not need to be heated, ventilated or air-conditioned.
- *Reduced Space Width* - Because the vehicles are stored by machines with precise control of the vehicle movement, automated parking facilities utilize much narrower stalls than self-park facilities. Additional stall width is not required for door opening clearances or for maneuverability into the stall. One can accommodate approximately 4 automated-parking stalls in the same width as 3 self-park stalls.
- *Lower Ceiling Height* - Because pedestrians do not circulate inside the garage, the ceiling height may be much lower. Approximately 3 automated parking floors can be provided for every 2 floors of a self-park garage where floor heights are typically on the order of 10 feet or more.

Advantages of Automated Parking

- *Tandem Parking Allowed* – Since vehicles are transported by machines on racks or pallets, automated parking facilities can stack vehicles end-to-end and move vehicles without the driver present. Tandem parking will then greatly increase the density and capacity of the parking facility.
- *Increased Capacity* - An automated parking facility can then accommodate two to three times the amount of parking spaces within the same volume as a self-park, ramp-access garage when one considers all the factors of reduced stall width, reduced ceiling height and tandem stalls.
- *No Stairs or Elevators* - Since the vehicle storage compartment is not accessible to the public, no stairs or passenger elevators are required. Only ladders and catwalks are required for access inside the storage vault.

Advantages of Automated Parking

- *Enhanced Safety & Security* - Because customers do not drive vehicles inside the storage area, there is no risk of vehicle collisions or property damage from errant drivers. Since the garage is not accessible to the public, it is much more secure than a ramp-access garage. Consequently, insurance rates are lower.
- *Reduced Lighting* - Since the interior of the facility is not occupied, only nominal security or emergency lighting is required. Utility costs for lighting and HVAC are then greatly reduced.
- *Enhanced Convenience* – The customer experience is often compared to automated, valet parking. The customer does not have to search for the last available stall on the top floor of a self-park garage, farthest from the stair or elevator and walk the additional distance to the patron's destination.

Disadvantages of Automated Parking

- *Reliability* – Better than 99.5% reliable based on downtime hours versus total operating hours, however, if redundant lifts/transfer devices/computers are used with flexibility to access all spaces, then reliability is virtually 100%. Also, Automated Parking System allows vehicles to be retrieved with manual operation of equipment.
- *Accessibility* – Service rate of 25-50 vph per entry/exit chamber not suitable for high volume arrival & departure traffic. Access design and queuing requirements may be cumbersome.
- *Cost* – Construction cost is approximately 2 times higher than a typical above-grade, ramp-access structure (Approximately $25,000 - $35,000 per space for mechanical parking equipment not including storage vault enclosure, fire protection, and utility services to the building). However, cost gap decreases for small and irregular sites. Operating cost is approximately twice as expensive as a cashier-less, ramp-access garage with automated pay stations or card-access operation.

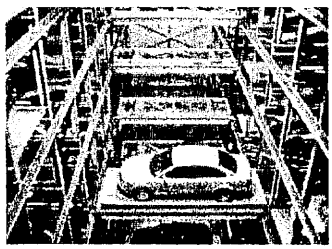
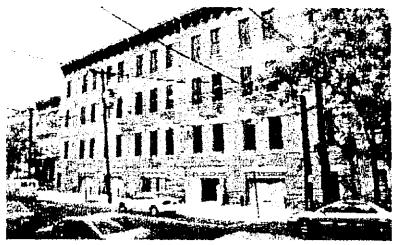
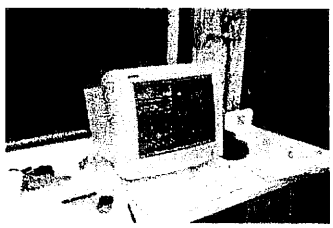
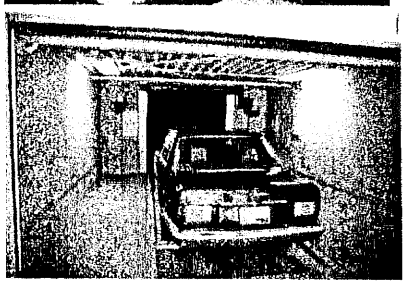
Any Successful Installations of Mechanical Parking?

- Over 500 installations worldwide – primarily in Japan, Asia, and Europe
- 1,344,114 mechanical parking spaces in Asia as of 1996. Number of spaces has doubled since 1991.
- Wöhr has provided approximately 300,000 spaces in Europe, Asia, Australia and the USA, since the company first produced double stacking systems in 1959.
- Two mechanical structures in U.S.
  - Hoboken, NJ – 324 spaces
  - Summit Grand Parc, Washington, DC – 74 spaces

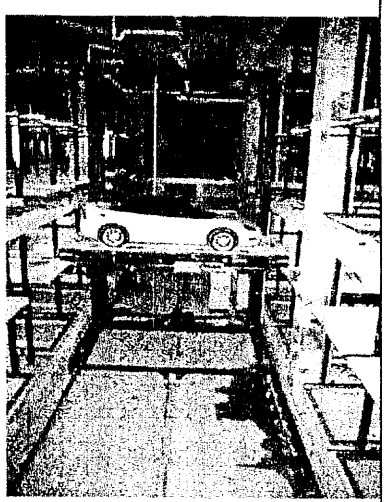
Hoboken, NJ Mechanical Parking Garage

- Design/Build Bid = $6,193,000 or $88/sf or $19,114/stall for Total Building with Machinery. Cost includes $300,000 for 5 year warranty, and $800,000 for brick façade. Add change orders for $186,000 delay costs due to foundation problems, $100,000 for environmental remediation, $200,000 for pile foundations, plus ? ?. (Total cost approximately $6.7 million as of 2/14/2000).
- Land cost adds $2 million.
- Footprint = 10,000 sf (100 ft by 100 ft) by 7 levels (70,000 sf total floor area).
- Capacity = 324 stalls or 216 sf/stall (tandem parking on both sides of shuttle corridor).
- Four entry/exit chambers for residential parking users.
- Two vertical lifts and 14 horizontal shuttles (2 per floor).

Hoboken, NJ Mechanical Parking Garage

Washington, DC Mechanical Garage



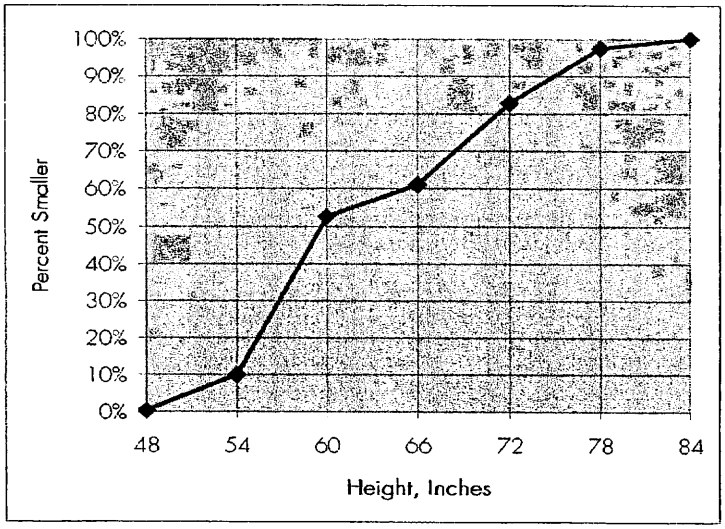
When is Mechanical Parking a Viable Option?

- Inadequate footprint to allow vertical vehicle circulation in a ramp-access garage.
- Height limitation does not result in adequate parking capacity and too expensive or not feasible to go underground. (Mechanical parking structure results in two to three times more spaces within the same volume as a self-park, ramp-access garage. Each floor height is 66% of ramp-access garage. Area efficiency is also approximately 66% of typical ramp access garage. Volume efficiency is then over 50% better than a ramp-access garage, or the parking capacity will be more than double that of a ramp-access garage in the same volume).
- High groundwater table limits depth and capacity of underground, ramp-access garage.

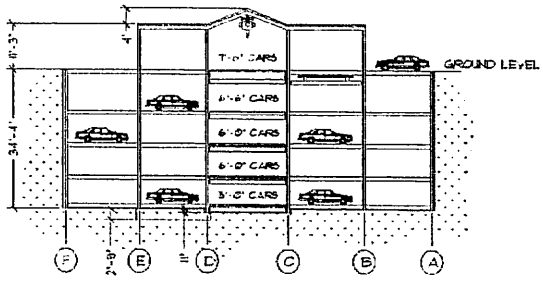
Schematic Design Approach

- Basic module consists of a row of 7-ft wide by 19-ft long stalls on each side of a 20-ft wide transport aisle or approximately 60-ft deep including walls.
- End-to-End Tandem parking on one side of transport aisle increases module depth to 80 ft.
- End-to-End Tandem parking on both sides of transport aisle increases module depth to 100 ft.
- Floor-to-floor height is typically 7-ft.
- Provide one lift or trans-lift for every 100-150 spaces.
- Provide one transfer chamber for every 25-50 spaces depending upon system.

Vehicle Height Study 1996-2001



Height Accommodation



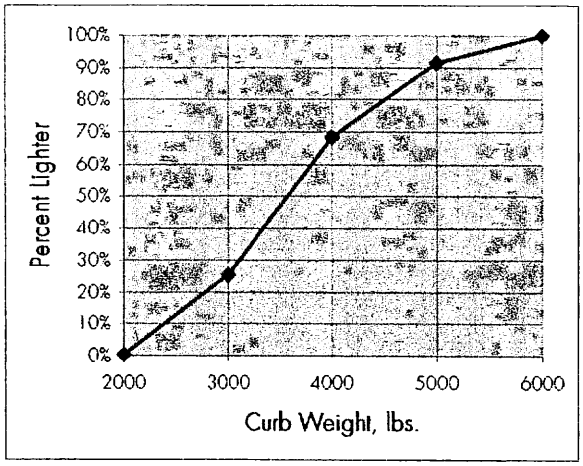
NOTES:
2'-6" DEEP PIT ONLY BELOW THE 88'-10" LONG VLC PORTION

TYPICAL CROSS SECTION

TOTAL SPACES: 683

ROBOTIC PARKING

Vehicle Weight Study 1996-2001

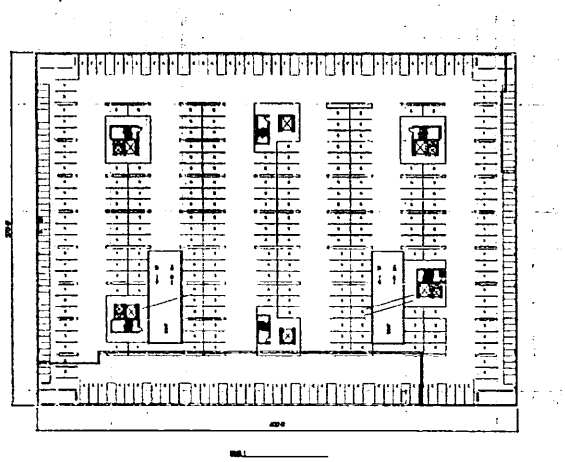


GVW = Curb Weight plus payload of up to 4000 lbs for larger pickups

Design Issues – Vehicle Considerations

- Vehicle Height
  - Large Vans, Pickups, SUV's – 7'0" maximum
  - Mid-size pickups, minivans, SUV's – 6'0" maximum
  - Standard Automobiles – 5'0" maximum
- Vehicle Width
  - Autos – 6'8"
  - Light Trucks – 6'8"
  - Minivans/SUV's – 6'8"
  - Compact Autos – 5'8"
- Vehicle Weight — Curb Weight — GVW
  - Ford F350, etc – 5,800-6,300 — 9,900-11,400
  - Expedition, etc – 5,000-6,800 — 6,800-8,600
  - Standard Automobiles – 5,000 lbs.

Self-Park Garage Efficiency

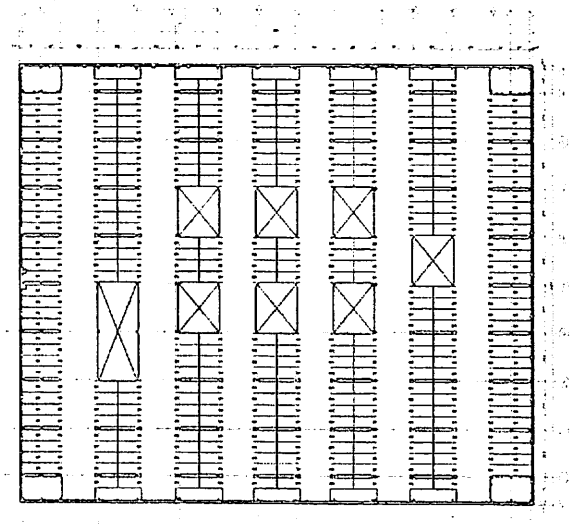


Capacity =
280 stalls/level

Area =
108,000 SF/Level

Efficiency =
386 SF/Stall

Mechanical-Access Parking Efficiency

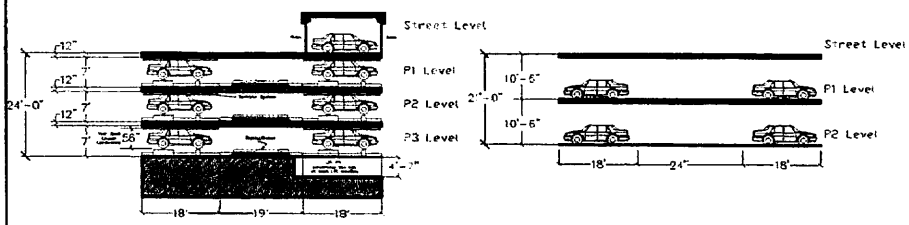


Capacity =
396 stalls/level

Area =
106,267 SF/Level

Efficiency =
268 SF/Stall

Volume Efficiency



MECHANICAL PARKING SYSTEM

396 Stalls/Level X 3 = 1188 Stalls

CONVENTIONAL PARKING GARAGE

280 Stalls/Level X 2 = 560 Stalls

Performance Issues

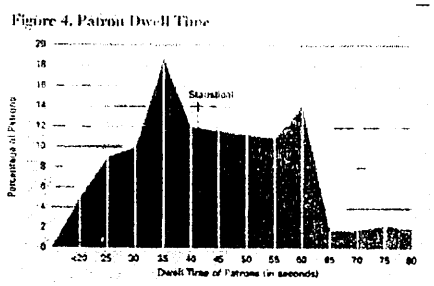
The performance of automated parking facilities is a function of the ability of the system to process customers without unacceptable delays and inconvenience. Experience at valet parking operations indicates that wait times on the order of 5 to 10 minutes are acceptable. The performance of an automated parking facility is then measured by the service rate or through-put of the system, and the reliability of the components of the system.

Service Rate

The service rate of an automated parking facility is measured by the number of vehicles stored or retrieved per hour. The time to transport a single vehicle from the transfer compartment to the storage space and back to the transfer compartment will determine the maximum service rate of the system. The time for each separate movement of the vehicle during storage and retrieval affects the total storage and retrieval time.

Storage Time = Machine Time + Dwell Time

- Machine Time commences when the system is activated and is the time it takes to pick up and store a vehicle or pick up and deliver a vehicle to the exit compartment. Averages 40-50 seconds. Maximum of 120 seconds
- Dwell Time is the time for a patron to enter the facility, retrieve all of their belongings, children, pets, etc and vacate the entry compartment. Conversely on departure, it is the time for the patron to enter the vehicle and vacate the exit compartment.



Source: Automated Parking: Two-Year Report Card by Gerhard Haag & Larry Byrnes of Robotic Parking published in PARKING Magazine, September 2004

Service Rate

Service Rate, vph	Tandem Parking?	Turn-tables?	Dwell Time?	Remarks
25	Yes	Yes	90	Shoppers/Visitors
30	Yes	No	90	Shoppers/Visitors
36	Yes	Yes	50	Residents/Employees
45	Yes	No	50	Residents/Employees
50	No	No	50	Residents/Employees

Note: Dwell time is the average time that it takes a patron to clear the entry compartment and activate the storage process, or the time it takes a patron to access their vehicle and depart the exit compartment. A 90 second dwell time should be used for unfamiliar patrons. A 50 second dwell time should be used for familiar, repeat users.

Service Rate (cont'd)

Figure 2. Relationship of Components and Capacities

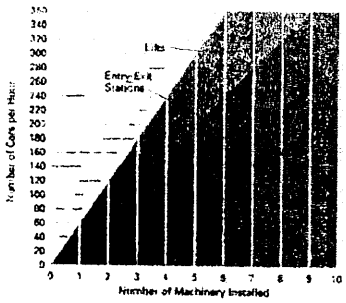
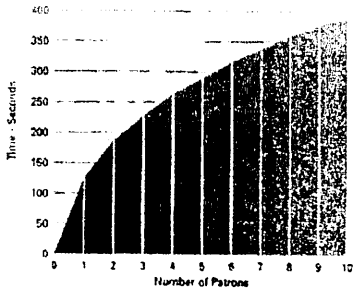


Figure 3. Actual Measured Time for Patrons Simultaneously Requesting Car

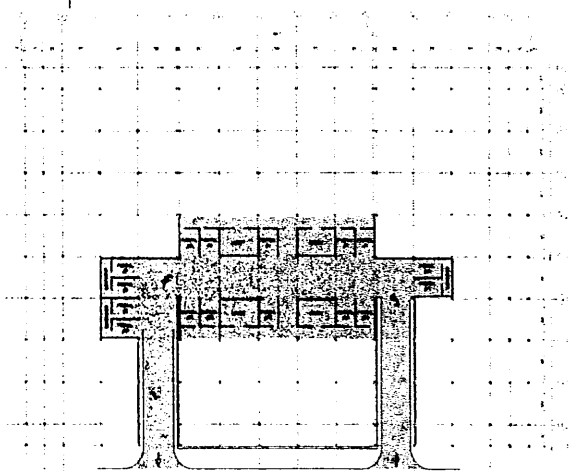


Source: Automated Parking: Two-Year Report Card by Gerhard Haag & Larry Byrnes of Robotic Parking published in PARKING Magazine, September 2004

Access Design Issues

- Access design is the same as other parking structures utilizing service rate of 25-50 vehicles per hour for arrivals or departures.
- Entry time dependent on following:
  - Time for patron to retrieve items from vehicle and activate system.
  - Time for vehicle to be transferred to shuttle and returned to service position is less than retrieval time.
- Retrieval time considerations:
  - Tandem parking configuration is 30 to 50% slower than non-tandem parking (must move lead vehicle to retrieve blocked vehicle).
  - Single storage/retrieval device (I.e. Trans-Lift) with vertical and horizontal motion capability is faster than separate vertical and horizontal transfer devices.
  - Retrieval time is no more than typical time for patron to access their vehicle on foot and drive to the exit in a ramp access garage.

Access Design Example



Capacity = 1188 Stalls

Peak AM Hour Traffic =
IN: 475 vph
OUT: 119 vph

Peak PM Hour Traffic =
IN: 238 vph
OUT: 416 vph

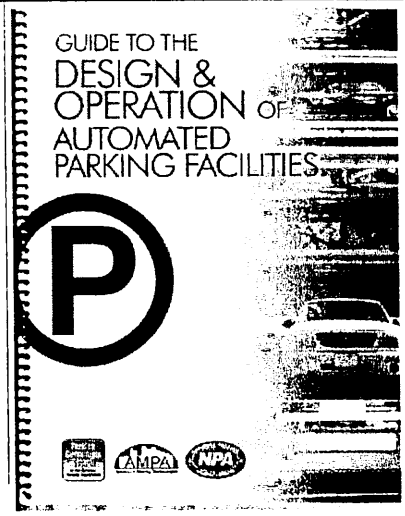
AM Portals = 594*1.2/50 = 14

PM Portals = 654*1.2/50 = 16

Summary

- If adequate land area is not available to construct a ramp-access garage, then mechanical-access garages may be the only viable parking option.
- If the land or building configuration results in an inefficient ramp-access garage (greater than 400 sf per stall), then a mechanical access garage may be a viable option.
- Where the convenience of attended valet parking is an option, then automated mechanical parking is a consideration.
- Where height limitations and/or depth limitations do not result in adequate parking capacity, then mechanical parking is a consideration.
- Where the height or depth of the structure excessively increases the construction cost, then mechanical parking may minimize those cost premiums.

Joint NPA/AMPA Publication



February 27, 2003

Principal Author: Don Monahan

Co-Authors: Vince Walls
Lee Lazarus

Reviewed By: Gary Cudney
Abe Gutman
Steve Shannon
Mary Smith

Purchase: www.npapark.org

Exhibit C

Manufacturer's web sites with videos & information

Parkplus Inc.

- Website – www.parkplusinc.com
  View projects, One York, Manhattan – view two videos

Unitronics

- Website – www.unitronics.com
  View automated parking video

SpaceSaver Parking Company of Chicago (Wohr)

- Website – www.spacesaverparking.com/projects/automaticparkingdebut.html
  View the site information – no video

Robotic Parking

- Website – www.robopark.com
  View guidelines – a good written description of the mechanical process

Automation Parking

- Website – www.adgorg.com/adg-project-baxter.html
  View video

Skyparks

- Website – www.skyparks.com
  View the four videos by pushing the "Video" word at the upper right hand corner of the site

U-ParkIt NA

- Website – www.uparkit.com

Westfalia Technologies, Inc.

- Website – www.westfaliausa.com

Metro Parking Systems

- Website – www.mp-parking.com

Klaus Multiparking

- Website – www.klaus-autopark.de

Exhibit D

Automated Parking Terms and Definitions

Through-put

Through-put is the number of cars in any one way flow which the system can process in a specified amount of time.

Machine Time + Dwell Time = Storage Time

Machine Time commences when the system is activated and is the time it takes to pick up and store a vehicle or pick up and deliver a vehicle to the exit compartment. Dwell Time is the time for a patron to enter the compartment, retrieve all of their belongings, children, pets, etc and vacate the compartment. Conversely on departure, it is the time for the patron to enter the vehicle, store all of their belongings, and vacate the exit compartment.

The total Storage Time is the Machine Time added to the Dwell Time and reflects the time it takes for a compartment to be activated by one patron up to the time it is ready to accept the next patron.

Pallet vs Rack

Originally, automated structures were designed to carry vehicles on pallets for storage. Recently, the technology has moved toward a rack (palletless) system, which lifts and stores a vehicle by its wheels.

Lifts and Shuttles vs Trans-lifts

There are two types of machinery used to store vehicles in an automated system:

1) A system using lifts (moving vertically) and shuttles (moving horizontally)
2) A system using Trans-lifts which are able to move both vertically and horizontally at the same time

Palm Street = 44 feet
Adjoining "Dwelling over Garage" = 21 feet

Table 1 - Summary of Key Site Plan Option Features

Design Comparisons	D3	H2	H3
Summary of Key Features	Self park structure with portions of upper levels removed to reduce building height impact.	Mechanical structure with portions of upper levels removed to reduce building height impact.	Mechanical structure oriented to reduce building height impact.
Building Footprint	34,350 s.f.	20,500 s.f.	20,500 s.f.
Gross Building Area	150,850 s.f.	118,750 s.f.	121,500 s.f.
No. of Levels	4 ½	5 ½	6
Building Height (35 ft.) *	39 ft.	41 ft.	37 ft.
Height exception needed?	Yes	Yes	Yes
Building Setback**			
Street yard (15 ft.)	8-10 ft.	0 ft.	0-10 ft.
Street yard exception needed?	Yes	Yes	Yes
Other yard (10 ft.)	10 ft.	10 ft.	25 ft.
Other yard exception needed?	No	No	No
Total Parking Spaces	445	491	565
Net New Spaces	366	412	486
Remaining Available Land Area for Future Use by Others	11,400 s.f.	8,700 s.f. 12,700 s.f.	19,800 s.f.
Remaining Public Use Area	6,700 s.f.	4,500 s.f.	3,000 s.f. 7,000 s.f.

* *Per the City's Zoning Regulations, building height is measured as the vertical distance from the average level of the ground under the building to the topmost point of the roof (structure). The average level of the ground is determined by adding the elevation of the lowest point of the part of the lot covered by the building to the elevation of the highest point of the part of the lot covered by the building and dividing by two. The building height does not include the elevator tower(s) which can extend ten (10) feet above the maximum building height. In the Office zone, the maximum building height is 25 feet; 35 feet with the approval of an administrative use permit.*

** *Per the City's Zoning Regulations, a minimum street yard of 15 feet is required. Other yards range from a minimum of five feet to ten feet, depending on building height.*

Because a self park design is less space efficient than a mechanical design, this design provides the least amount of new parking spaces (366) in 4 ½ levels and the smallest amount of remaining land area (approximately 11,400 s.f.) for a future use by others.

ATTACHMENT 2

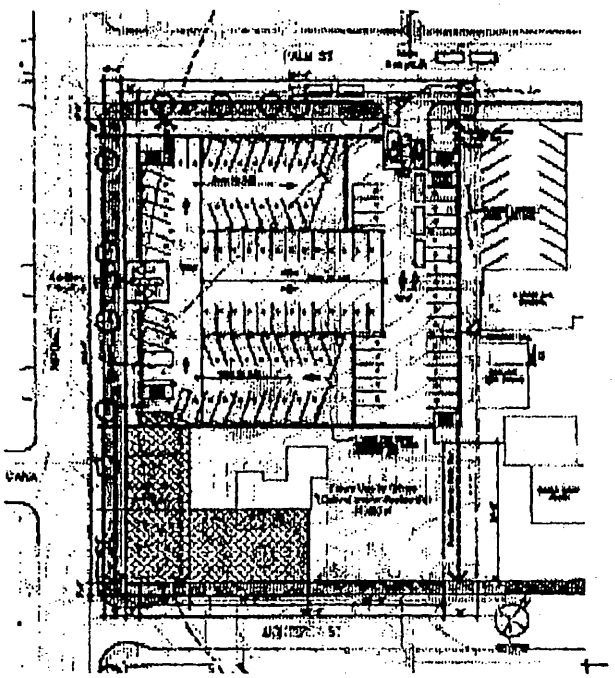


Figure 1 - Site Diagram for Option D3

Site Plan Option H2 locates the parking structure mid-block between Monterey and Palm Streets leaving room for other uses (residential, office and/or cultural) to be constructed on Monterey and Palm Streets in front of the structure and a public use area at the corner of Nipomo and Monterey Streets. Because users do not enter the mechanical structure, direct access is provided to the nearest public right of way, but not directly through the site to Monterey Street as desired by Council. A total of 412 net new parking spaces are provided within 5 1/2 levels of parking, approximately two of which are located below grade. Additional parking levels have not been located beyond 20 feet below grade due to added costs for waterproofing the structure. Council may recall that groundwater was encountered 30 feet below the surface in one boring taken a few years ago.

With this design, the five residences are relocated or demolished. Parking spaces (totaling 70 spaces) have been removed from the upper levels to step the structure height back toward the center of the structure thus reducing the visual impact of the building height as seen from Monterey Street and the adjoining residential properties to the northeast, including the Latimer Adobe. As an option, one less section of parking could be removed from Section B-B and Section A-A, which would add 39 spaces to the structure. The parking structure's height is measured as follows:

Monterey Street =	25 feet
Nipomo Street =	43 feet
Palm Street =	41 feet
Adjoining "Dwelling over Garage" =	14 feet

B1-24

ATTACHMENT 2

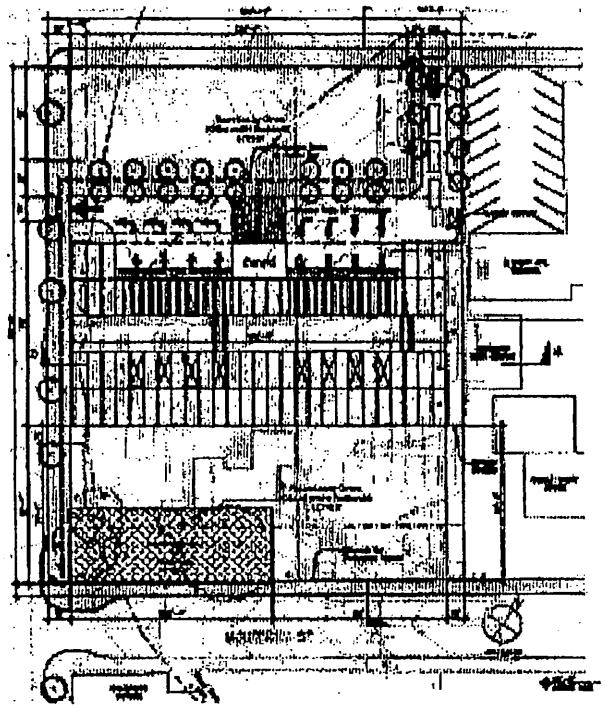


Figure 2 - Site Diagram for Option H2

Site Plan Option H3 locates the parking structure diagonally on the site providing the widest separation between the parking structure and adjoining residences. With a separation of a minimum of 40 feet between the parking structure and adjacent residences, the upper floors of the structure do not need to be stepped back to reduce visual impacts. This design results in the most efficient mechanical design providing the largest number of new parking spaces (486) within 6 levels. Again, additional levels have not been located beyond 20 feet below grade due to added costs for waterproofing the structure. With this design, two public spaces (totaling 3,000 s.f. and 7,000 respectively) are created at the property corners of Palm/Nipomo and Monterey/Nipomo Streets and direct pedestrian access can be provided through the public space to Monterey Street. The single family residence at 633 Palm could remain until the 19,800 s.f. "Future Use by Others" area is redeveloped. The parking structure's height is measured as follows:

Monterey Street =	33 feet
Nipomo Street =	43 feet
Palm Street =	41 feet
Adjoining "Dwelling over Garage"=	30 feet

Considering only design features, Site Plan Option H3 best fulfills the City's goals for a parking structure at this location.

B1-25

ATTACHMENT 2

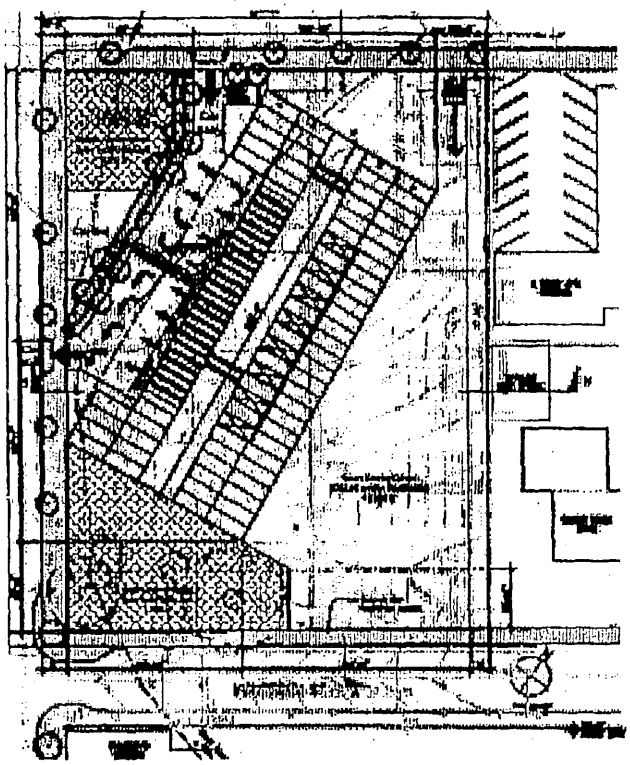


Figure 3 - Site Diagram for Option H3

Mechanical vs. Self- Park Cost Comparisons

As requested by Council, a cost comparison for the construction, maintenance, and operation of the three site plan options was developed.

Table 2 – Construction Cost Comparison

Construction Cost Comparison	D3	H2	H3
Initial Capital Cost/Net New Space	Self park structure	Mechanical structure	Mechanical structure with building orientation
Construction [1]	$24,800	$47,800	$46,500
Soft Cost (Design/Construction Management/Inspection/Permits/Fees)	$8,700	$16,700	$16,300
Total per net new space	$33,500	$64,500	$62,800
Number of spaces	x 366	x 412	x 486
Total Construction Cost	**$12,261,000**	**$26,574,000**	**$30,520,800**

B1-26

ATTACHMENT 2

Table 3 – Operational Cost Comparison

Operation Cost Comparison	D3	H2	H3
Annual Expenses/Gross New Space	Self park structure	Mechanical structure	Mechanical structure (per Ken Schwartz)
Routine/Preventive Maintenance[2]	$140	$500	$500
Operation [3]	$425	$240	$235
Utilities	$55	$180	$175
Security	$67	$36	$35
Insurance	$18	$18	$18
Miscellaneous	$85	$85	$85
Total per space	$790	$1,059	$1,038
Number of spaces	x 445	x 491	x 565
Total Annual Operating Cost	**$351,500**	**$520,000**	**$586,500**

Notes:
1) Construction costs are in current dollars and derived from recently developed projects including the 919 Palm Street structure.
2) Maintenance costs assume mechanical systems will be maintained by a mechanical service provider adding additional cost to routine maintenance.
3) Assumes central cashiering for self-park and pay-on-foot revenue collection for mechanical.
4) Equipment/structure long-term repair and replacement costs are not included.
5) Soft costs computed @ 35% do not include land, financing, contingency, or escalation.
6) Initial software costs are included in construction cost. Software updates should not add costs to the annual expenses. Standard maintenance associated with software is a part of the Routine/Preventative Maintenance line item. Ownership of the software should be factored into the initial contractual agreements between vendor and client.
7) At least one additional full time staff person will be needed for a new structure regardless of its type.

As expected, the mechanical structures are more costly to construct and maintain because of the mechanical parking systems, however there are additional reasons for the cost difference. Other cost factors include:

1. **Site Constraints.** The Palm-Nipomo site offers ample space to build an efficient self-park structure. If the size or dimensions of the site were substantially constrained, it would cost more to build a self park design. Because a mechanical design can be accommodated in a much smaller footprint than a self-park design, the efficiencies of a mechanical design improve when size constraints limit a self-park design at the same location.

2. **Construction Components.** A short-term mechanical parking structure for public use requires twice as many portals (entrances and exits) and associated mechanical equipment than a long-term private mechanical structure such as Hoboken, New Jersey (see Attachment 7, Comparison of Existing Mechanical Structures).

3. **Software.** A software program to operate the structure is required and needs to be updated to operate the mechanical features. Ownership transition of the software needs to be

considered during the contract development to avoid later disputes should the vendor go out of business or change business practices.

4. **Preventive Maintenance.** The mechanical design requires maintenance of numerous mechanical components that are not included in a self-park design. A mechanical service provider is needed to maintain the mechanical components.

5. **New Technology.** Because the concept of mechanical parking is relatively new to the United States, there is not a lot of competition and therefore companies selling and maintaining the mechanical systems can charge what the market will accept.

The consultant researched existing and proposed mechanical structures throughout the world (see Attachment 7, Comparison of Existing Mechanical Structures) to learn more about the pros and cons of mechanical parking from other projects. All research shows that the mechanical parking sites were constrained in such a way that made the cost of mechanical parking more feasible. Additionally, the structures were designed to accommodate the demand for residential use (not general public use) thus requiring fewer portals which reduced the cost to build and operate the structures. All constructed and operational examples were also much smaller in scale with the exception of the Hoboken structure that was designed to accommodate 320 vehicles. Finally, the consultant learned that projects that included a partnership between the mechanical system provider (vendor) and the mechanical service provider had fewer operational problems.

Although land cost was not considered in the comparison, it is also a factor. If land cost or availability was as constrained as it is in other countries, we would have fewer options to consider (such as purchasing neighboring properties) when developing a parking facility.

Staff Recommendation in Light of Significant Cost Differential

As of the date of this report, no public agency in the United States has opted to build a mechanical structure. It is staff's hope that once the technology becomes more mainstream, the costs to construct and operate a mechanical design will decrease, making it a feasible option for future City parking facilities. Until then, it is difficult for staff to support a mechanical design because of costs and the potential for other uncertainties. Given the current significant cost differential between mechanical and self park structures, staff recommends that Council consider **Site Plan Design Option D3 (self park)** as the preferred design at this time. Although the mechanical design (H3) is a much more efficient use of space, has the least amount of visual impact to the adjoining residential uses, and provides the largest remaining land area for a cultural facility, the costs of a mechanical structure are far too high to pursue at this time.

Palm-Nipomo: Where to From Here, or, "And if we build it, will the come?"

There are several outstanding issues which remain unresolved at this point that could affect the consideration of the next steps in the Palm-Nipomo project should be. Those questions are as follows:

Exhibit F

Observed Automated Parking Facilities

1706 Rittenhouse Square Street, Philadelphia, PA

This parking facility contains 64 spaces which supports the parking needs of a 32 unit *high-end* condominium project. All of the parking spaces are below grade in an open volume that is about 44 feet deep. The parking system is a German (Wohr) made palletized type that is about one month away from being operational. The distributor (for Wohr), assembler and maintenance company is Spacesaver Parking out of Chicago (they have a parts/maintenance center near Washington, DC). The parking system is housed in a large open volume about 100' long by 80' wide and 44' deep. It is fully sprinkled at the roof of the parking volume, has a low volume air change system and minimum lighting. The single "car lift" system is capable of moving horizontally on a track while simultaneously lifting (or lowering) vehicles to (or from) their parking space and can also turn the pallet (which the vehicle is sitting on) 180 degrees to change from "entry" direction to "exit" direction. There is one "off-street" queuing length for the one in-bound vehicle lane and one interior queuing length for the one existing vehicle lane, which is probably adequate for a 32-unit condominium project. The installation cost was ~$40,000 per space for only the metal frame, mechanical equipment and electronic hardware; that cost does not include any of the physical building structure that encloses it (in this case an underground concrete box within the water table, plus the sprinkler, ventilation & lighting systems). The estimated maintenance cost is $115 per month per vehicle. In my discussion with the project manager for the developer, he stated that every part of the vehicle storage framework and its moving parts along with the elevator and it's moving parts have such extremely tight alignment tolerances (~1/8"), that any small movement might cause misalignment between the parts and the system will shut down until it can be re-aligned. (this could be a problem in an earthquake prone area). Some small extra mechanical parts are being stored at an off-site area for anticipated needs.

101 South Juniper Street, Philadelphia, PA

This parking facility will have 224 parking spaces and is anticipated to be for both commercial monthly parkers and public hourly parkers. The project is a retro-fit of an old parking structure that had a man-operated vehicle elevator, and had to be re-designed within existing walls, columns, stairs and floor-to-floor heights. This project is about eight months away from completion (assuming no further complications). The parking system is an Italian firm (Sotefin-Elecon) and is a non-palletized system because of restricted vertical clearances of the existing structure. The distributor (for Sotefin-Elecon), assembler and maintenance company is Atlas Technologies out of Michigan. The typical parking level provides for 25 vehicles (some compact only) and had six elevated parking levels of minimum height (about 7 foot floor-to-floor). A partial seventh level was added to provide for higher vehicles (such as SUV's). In this parking system, there are two hoists (which do not move horizontally) that connect to

each level and then the cars are transferred to trolleys to move the vehicles horizontally to their appropriate space. This structure has three entry lanes on one street (one can accommodate ADA vehicles) with no off-street queuing and three exit lanes on another street (one can accommodate ADA vehicles) with no exit vehicle queuing before the sidewalk. This ground level configuration will cause queuing into the street for vehicles entering the facility and will substantially slow the delivery time of vehicles for customers waiting to receive their vehicle to leave the facility. No cost per vehicle was given for this facility, except the comment that no one came out in the black on this project. No one wanted to guess on what the maintenance costs might be. No extra mechanical parts are being stored locally, but will rely on Michigan warehousing for shipment and maintenance personnel as needed.

916 Garden Street, Hoboken, NJ – 296 useable parking spaces

This parking facility was the first automated parking facility in the United States. The system was eventually designed and operated by an Israeli firm called Unitronics. It houses 295 parking spaces for nearby apartment residences on a monthly basis only. This was a City project to relieve day and night street parking in a densely populated apartment area. The site for this facility is 100 feet square. In order to reduce the queuing out onto the street for entry traffic, there are three separate entry/exit driveways, a pedestrian opening to a waiting area and exit driveways along the public sidewalk.

This number of entries and exit driveways onto the street helps to reduce the queuing of vehicles out onto the street for entering and attempts to keep the waiting time down for the patrons wanting to use their vehicles to go somewhere. This palletized system has two hoists (elevators), one at each end, and has two trolleys on each level to move the vehicles horizontal. In this facility, foldable mirrors are a must. The City states that the time to either store or retrieve a vehicle takes between 3 to 6 minutes, but in peak entry times, the vehicle queuing can be as much as 10 vehicles out onto the narrow single-lane one-way street. During the morning exit peak, patrons may have to wait up to 25 minutes. The four patrons that interviewed were very-dissatisfied with the facility. The maximum exit capacity of this facility was stated at 20 vehicles/hour. The desired staffing for this facility is three full-time persons including a City staff person on call 24/7. A lot of adjustments are needed to keep the system operating properly and the City does its own continuous maintenance and repairs except for the software programming. The parking area is heated due to temperature expansion/contraction of metal miss-aligning the tight tolerance of the moving parts.

123 Baxter Street, Manhattan, NY – 67 parking spaces

This is a small palletized system in the heart of the Chinatown area. While this facility is beneath a new condominium building, it has only a few monthly patrons and the rest are used by hourly use patrons. Because all of the parking is below grade and the entry and exit compartments are at grade, two lifts are required to lower the vehicles from the street level compartments to the below-grade automated parking system. The system has one vehicle elevator that also moves horizontally as-well-as rotates the vehicle 180 degrees to face the vehicle in the exit direction for the retrieval operation. Because this facility has hourly patrons use, a full-time person is needed at the street level to help guide hourly patrons in the operation of the system. The website video states that it takes about two and one-half

minutes to retrieve the vehicle. This system was designed and built by Automotion Parking Systems. The facility is about three years old and has significant use due to the hourly users, but seems to be operating with few problems.

55 Avenue of the Americas, Manhattan, NY – 40 parking spaces

This facility is a non-palletized system (meaning fewer moving parts)and is located adjacent to and for a condominium building. The parking spaces are sold with the condo for an additional $225,000. There are no tandem parking spaces in this facility and little (if any) peak volumes, so it's single elevator/trolley are adequate for parking and retrieving the vehicles. The single entry chamber utilizes a turntable to face the vehicle in the exiting direction before it is taken by the elevator. There is no personnel needed at this facility. This facility was designed and built by ParkPlus, a Swiss company. This company is about to complete another automated parking facility in Towson,\ MD, a northern suburb of Baltimore, for about 410 spaces. This Towson structure accommodates only monthly residential patrons.

910 15th Street NW, Washington, DC – 74 parking spaces

This facility is similar to the 1706 Rittenhouse Square project in that it was build by the sane firm but has been in use for about eight years. It is an older version without the new improvements that Rittenhouse is now using. All of the parking patrons are monthly parkers (residential and office). The site's shape (an "L" shaped site) required that both the entry and exit compartments at grade level have turn tables to align the vehicles with the parking framing below, but also both the compartments are at a 45 degree with the street to facilitate easy entry and exit through a single width driveway opening at the street property line. All of the parking is below grade without any tandem spaces (due to property dimensions). A lift lowers and raises the vehicles to and from the compartments so that the single elevator/Trolley can transfer the vehicle and move it to its assigned location. This system (Wohr) also makes pallet-less systems and either system can be manufactured in the U.S. to avoid currency differences between the Euro and the Dollar.

Exhibit G

Parking Structure #6 Analysis of Automated Entry "Processing"

Assumption: Total number of parking spaces in structure - 700 spaces

Entering Demand

Peak hour entering volume - 35% = 245 vehicles/hour = 4.1 vehicles/minute (average)

1 vehicle every 14.7 seconds (average)

Entering Capacity

Assumptions: Average entering dwell time (patron time in compartment) plus average delivery time (mechanical operation of handling vehicle) based on one elevator serving three entry compartments - 3 minutes (180 seconds) or

1 vehicle every 60 seconds per three entry chambers (180/3)

Peak entering capacity of facility (10 entry compartments) - 3.3 vehicles per minute (average)

1 vehicle every 18 seconds

Queuing Demand

Since the demand exceeds the capacity, the queuing will accumulate up to 46 vehicles just during the peak hour. We estimate that the structure will be able to accommodate (off-street) 16 queued vehicles, causing the additional 26 vehicles to queue out onto Second Street in the driving lanes. It will take fourteen minutes for the last vehicle of the peak hour to reach an entry compartment.

Exhibit H

Parking Structure #6 Analysis of Self-Parking entry "processing"

Assumption: Total number of parking spaces in structure - 700 spaces

Entering Demand

Peak hour entering volume - 35% = 245 vehicles per hour = 4.1 vehicles/minute

1 vehicle every 14.6 seconds (average)

Entering Capacity

Two entry ticket dispensers – 2 x 3.6 vehicles per minute = 7.2 vehicles per minute

Queuing Demand

Entering Demand ÷ Entering capacity = Traffic intensity

4.1 ÷ 7.2 = .57 = three queuing spaces

Exhibit I

Parking Structure #6 Analysis of automated exit "processing"

Assumption: Total number of parking spaces in structure - 700 spaces

Exiting Demand

Peak hour exiting volume - 35% = 245 vehicles/ hour = 4.1 vehicles/minute (average)

1 vehicle every 14.7 seconds

Exiting Capacity

Assumptions: Average exiting dwell time plus average delivery time of one elevator serving three exit compartments - 3 minutes (180 seconds) or

1 vehicle every 60 seconds per three exit compartments (180/3) (average)

Peak exiting capacity for 9 exit compartments - 1 vehicle every 20 seconds = 3.0 vehicles/minute

Queuing Demand

Since the demand exceeds the capacity, the number of queuing patrons (in the waiting room) waiting to have the vehicle delivered will accumulate up to 65 just during the peak hour. The wait time for the last patron in the peak hour would be twenty-two minutes.

Exhibit J

Parking Structure #6 Analysis of Self-Parking Exit "processing"

Assumption: Total number of parking spaces in structure - 700 spaces

Exiting Demand

Peak hour entering volume - 60% = 420 vehicles per hour = 7.0 vehicles/minute

1 vehicle every 8.6 seconds (average)

Exiting Capacity

Two exit lanes – 2.x.3.9 = 7.8 vehicles per minute

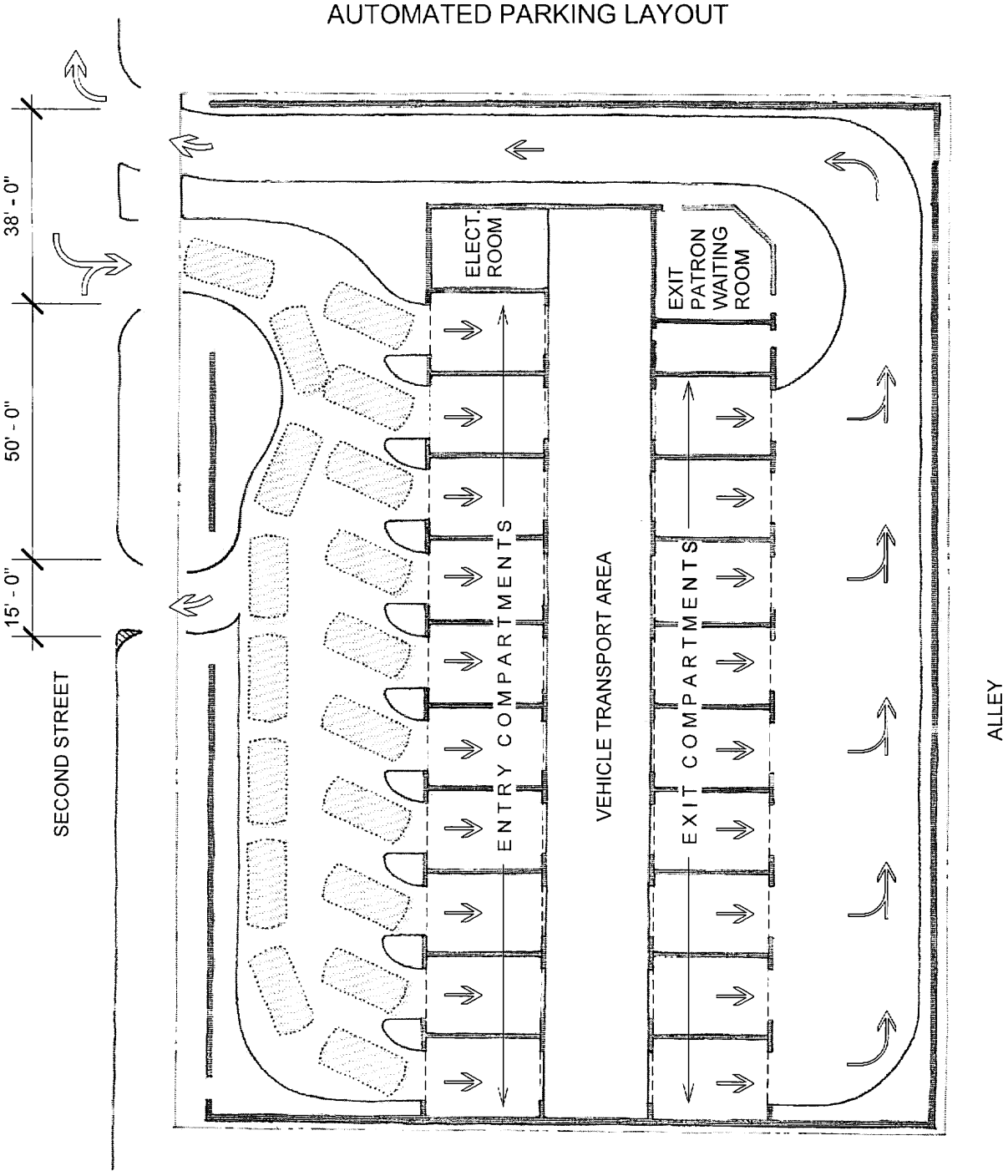
Queuing Demand

Entering Demand ÷ Entering capacity = Traffic intensity

7.0 ÷ 7.8 = .9 = eight queuing spaces

COSM PARKING STRUCTURE #6
1431 SECOND STREET

AUTOMATED PARKING LAYOUT



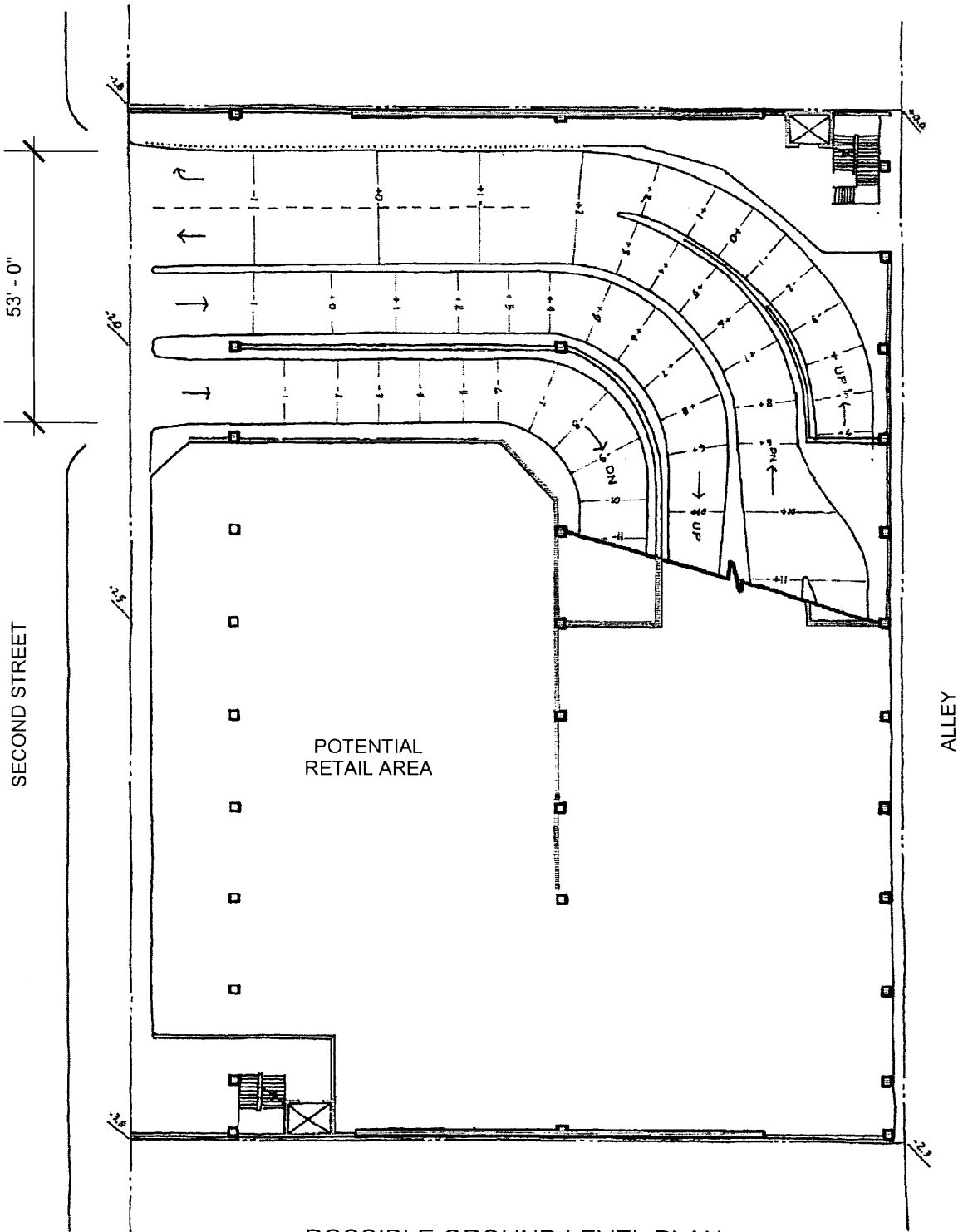
POSSIBLE GROUND LEVEL PLAN

EXHIBIT-K

Scale: 1" = 30'-0"

COSM PARKING STRUCTURE #6
1431 SECOND STREET

SELF PARKING LAYOUT



POSSIBLE GROUND LEVEL PLAN

EXHIBIT-L

Scale: 1" = 30'-0"

Firm Profile

IPD is the leading expert in developing parking solutions. The firm's reputation for innovative design, value and focused expertise in parking design has been earned through nearly 40 years of dedicated work in public and private projects across the nation as well as internationally. IPD's proven design process tightly integrates architectural design, structural engineering and parking consulting services, resulting in a synthesis of form and function. Nationally recognized for award-winning work, IPD is committed to achieving the highest level of customer satisfaction by delivering quality, efficiency and value. Whatever the requirements, our priority is always to meet our clients' needs.

FACTS

Founded:	1969
Headquarters:	Los Angeles, California
Locations:	Los Angeles, Irvine, Alameda, Sacramento
Projects:	5000+
Employees:	55

SELECTED RECENT AWARDS

2010 Sony Electronics Headquarters Parking Structure
- International Parking Institute (IPI) Award of Excellence, Category II
- International Parking Institute (IPI) Award of Merit, Catergory V

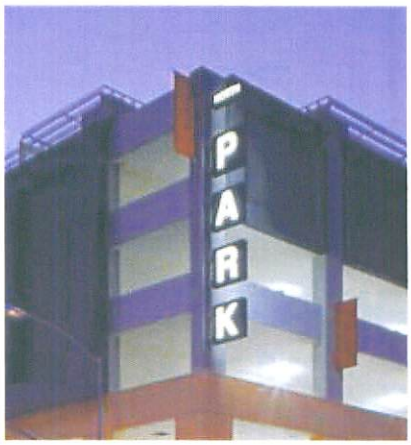
2009 East Los Angeles College Parking Structure
- Los Angeles Architectural Award

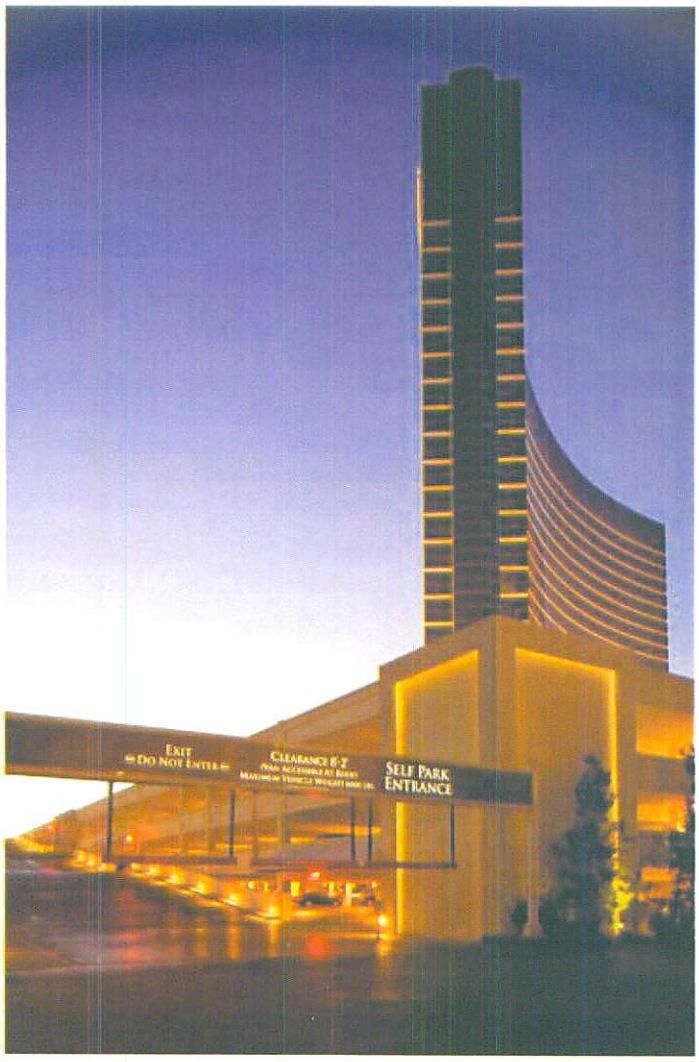
Irvine Transportation Center
- American Public Works Association (APWA), Project of the Year Award
- International Parking Institute (IPI) Award of Merit

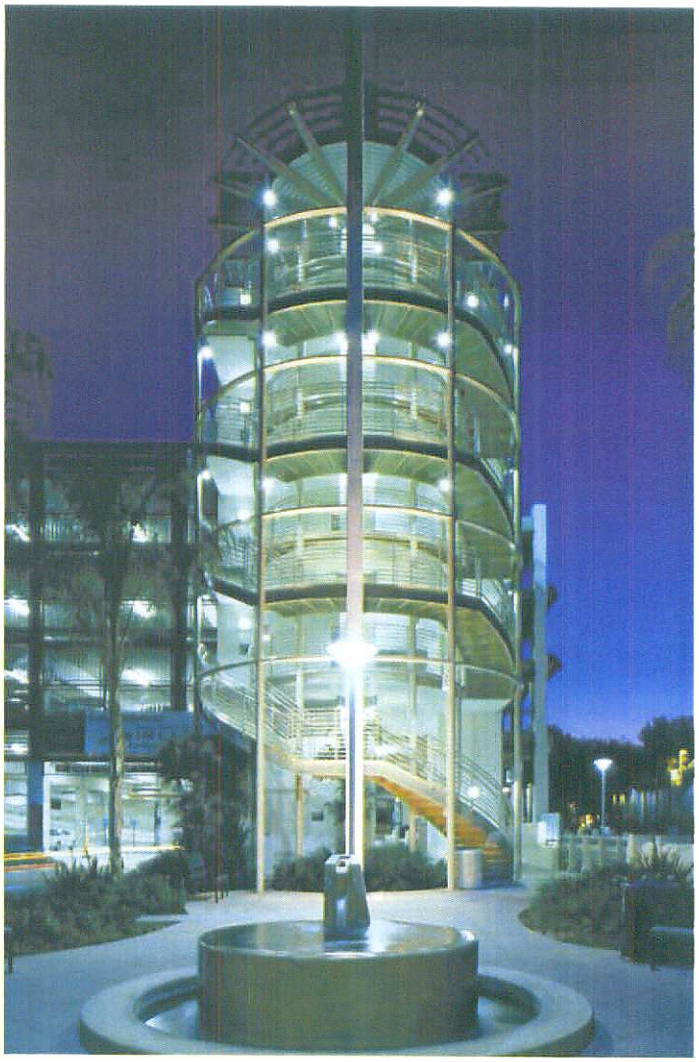
2008 Santa Monica Civic Center Parking Structure *(this project has won multiple awards)*
- Los Angeles Architectural Award
- International Parking Institute (IPI) Award of Excellence

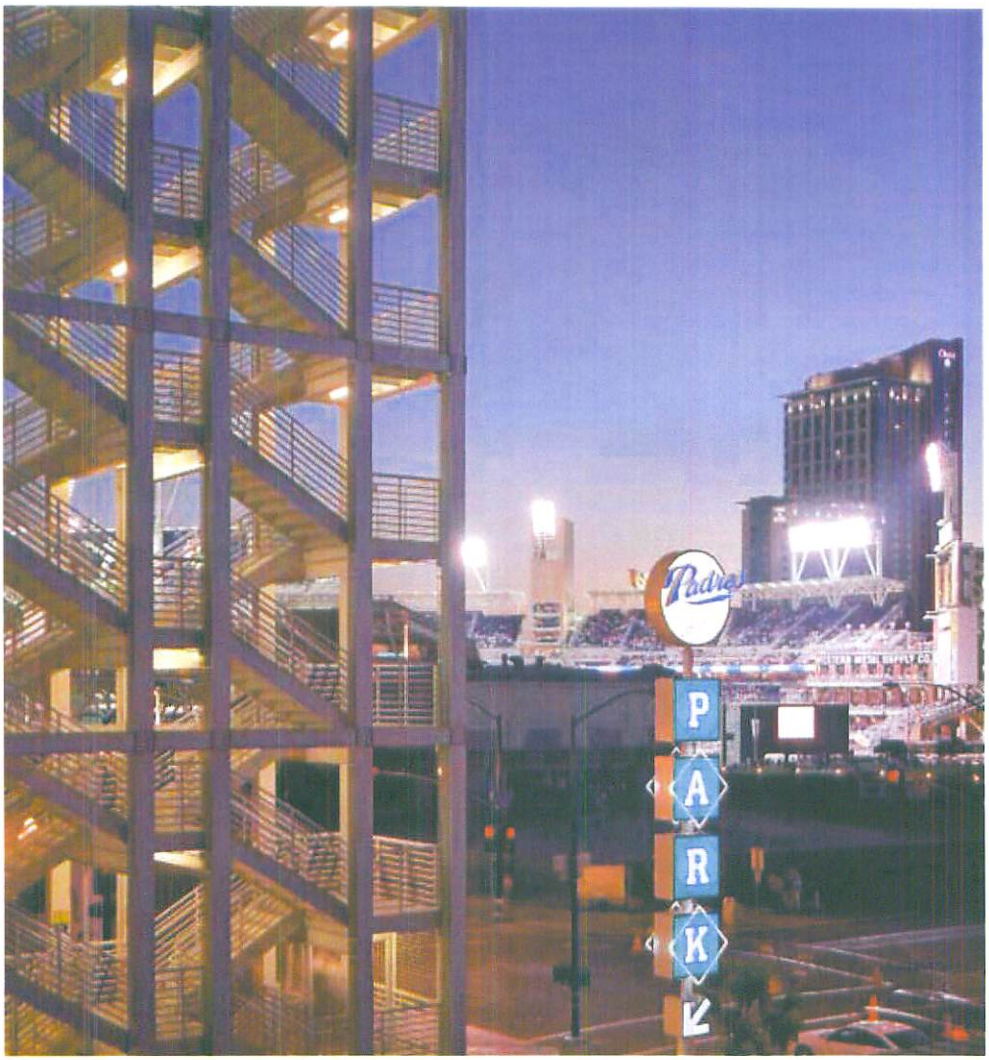
CAPABILITIES

Architecture
Structural Engineering
Integrated Sustainable Design
Masterplanning
Demand Studies
Feasibility Studies
Functional Design
Value Engineering
Facade Design
Access & Revenue Control Systems
ADA Compliance
Efficiency Reviews




EXIT
DO NOT ENTER
CLEARANCE 8'-2"
SELF PARK
ENTRANCE



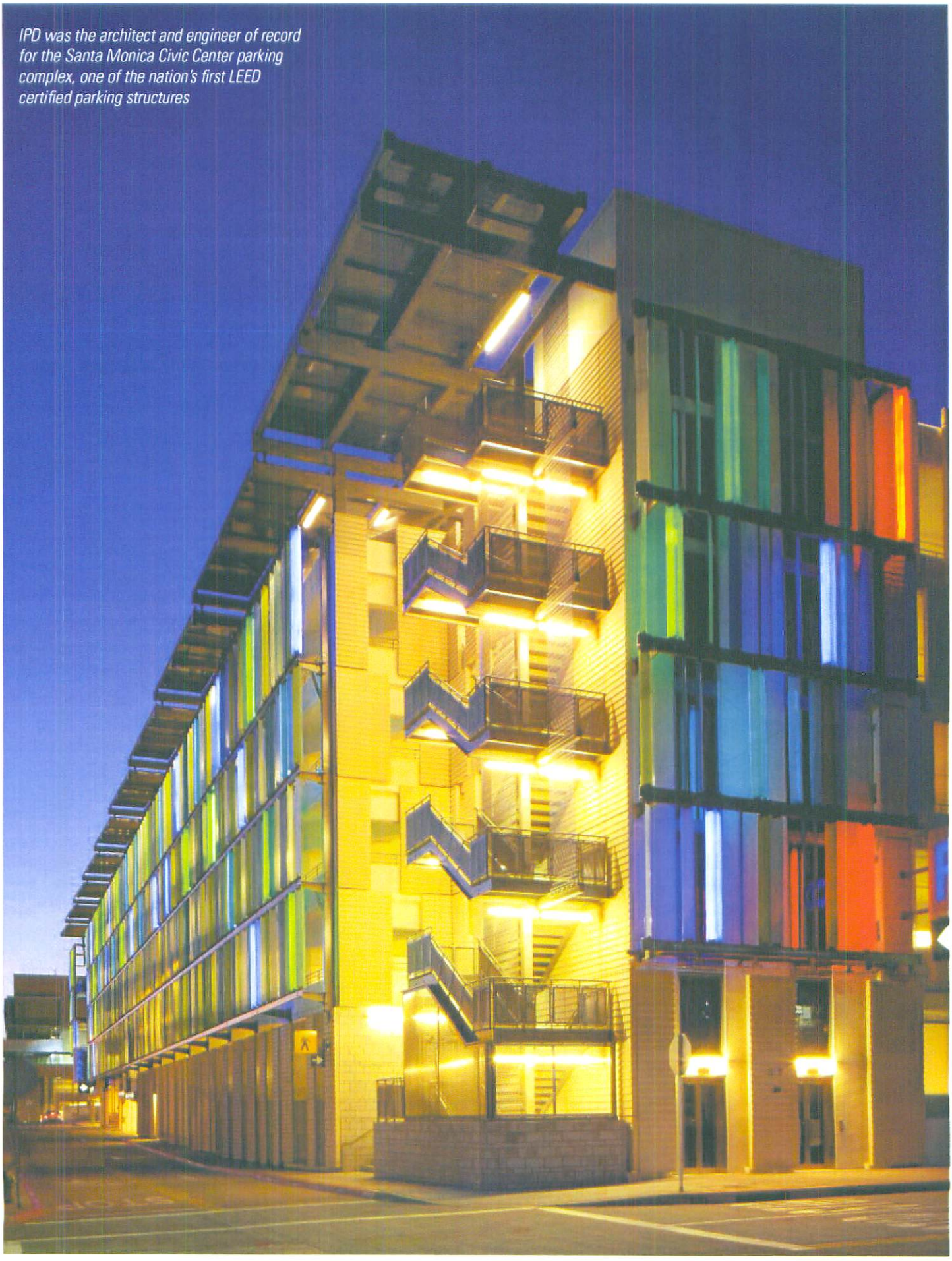


Design Approach

International Parking Design approaches the design of a parking structure as a building type that must be complementary to the buildings it serves and that must respect, reflect and enhance the architectural context of the surrounding community. Since the parking structure will be the first and last experience visitors and employees have of their trip to the area, it must offer a comfortable, secure, pleasant and easily comprehended environment.
The modern parking structure is becoming more complex as it frequently serves a mix of uses: retail, entertainment, commercial and residential. Therefore, it must be more than a parking garage; it must be a people place.

CAPABILITIES
IPD has expertise developing parking solutions for dozens of California cities, below is a sampling:

Anaheim
Berkeley
Beverly Hills
Buena Park
Burbank
Chico
Claremont
Culver City
Davis
Downey
Emeryville
Glendale
Hawthorne
Huntington Beach
Huntington Park
Irvine
Laguna Beach
Long Beach
Los Angeles
Merced
Monrovia
Montebello
Monterey
Mountain View
Oakland
Ontario
Orange
Palo Alto
Pasadena
Pleasant Hill
Rancho Cucamonga
Riverside
Sacramento
San Bernardino
San Diego
San Fernando
San Francisco
San Jose
San Luis Obispo
Santa Ana
Santa Clarita
Santa Monica
Seal Beach
Studio City
Temecula
Thousand Oaks
Ventura
West Hollywood
Whittier



IPD was the architect and engineer of record for the Santa Monica Civic Center parking complex, one of the nation's first LEED certified parking structures