

A photograph of a modern multi-level parking garage. The structure features several levels of parking, each supported by a grid of steel beams and columns. Yellow mechanical arms, likely car lifts, are visible throughout the space. In the foreground, a dark-colored sedan is parked on one of these yellow lifts. The background shows other levels of the garage, with more cars parked on lifts. The lighting is dramatic, coming from overhead fixtures that cast long shadows and highlight the metallic surfaces.

# MAN

A red oval shape containing a white stylized letter 'V'. This graphic element is positioned to the right of the word 'MAN' in the large title.

**By Don Monahan, P.E.**

# MACHINE

## **Is robotic parking right for your project?**

**R**obotic parking structures, more commonly referred to as automated vehicle storage/retrieval systems (AVSRS), are rapidly gaining momentum and popularity. Does an AVSRS garage make sense for you?

The first two automated vehicle storage systems in the U.S. were completed in 2002 in Hoboken, N.J. (314 spaces) and Washington, D.C. (74 spaces). It took another five years before the third one was built in New York City's Chinatown (67 spaces). However, hundreds of these garages have been

built in Europe and Asia since the 1960s, and more recently, some very large automated garages (more than 1,000 spaces) have been built in the United Arab Emirates and the Middle East. Since 2007, another 25 automated garages have been built or are under construction in the U.S. (see Table 1).

**Table 1: Current and Planned AVSRS Garages in the U.S.**

<b>314 spaces</b> , 916 Garden Street, Hoboken, N.J.	<b>440 spaces</b> , I-595 & US-1, Fort Lauderdale, Fla.
<b>74 spaces</b> , 900 15th St NW, Washington, D.C.	<b>270 spaces</b> , 1504 Coney Island Ave., New York, N.Y.
<b>67 spaces</b> , 123 Baxter St, New York, N.Y.	<b>300 spaces</b> , 123 Beverly St., Boston, Mass.
<b>40 spaces</b> , 55 Avenue of the Americas, New York, N.Y.	<b>409 spaces</b> , 212 Washington Ave., Towson, Md.
<b>64 spaces</b> , 1706 Rittenhouse Square St., Philadelphia, Pa.	<b>53 spaces</b> , 148 E. 24th St. New York, N.Y.
<b>224 spaces</b> , 101 Juniper St., Philadelphia, Pa.	<b>132 spaces</b> , 275 Seabreeze Ave., Brooklyn, N.Y.
<b>24 spaces</b> , 418 Jessie St., San Francisco, Calif.	<b>25 spaces</b> , 20 Grand St., Brooklyn, N.Y.
<b>400 spaces</b> , Johnson Ave., Coconut Creek, Fla.	<b>200 spaces</b> , 8300 Santa Monica Blvd, West Hollywood, Calif.
<b>40 spaces</b> , Crystal Springs Resort, Hamburg, N.J.	<b>853 spaces</b> , Old Capital Green, Jackson, Miss.
<b>298 spaces</b> , Exchange Place, Wichita, Kan.	<b>460 spaces</b> , Park Terrace, W. New York, N.J.
<b>226 spaces</b> , Costa Hotel, Hollywood, Fla.	<b>249 spaces</b> , The Metropolitan, Atlantic City, N.J.
<b>55 spaces</b> , Elliot Museum, Stuart, Fla.	<b>139 spaces</b> , Collins Ave, Miami, Fla.
<b>385 spaces</b> , UCLA Med. Center, Santa Monica, Calif.	

## Designs

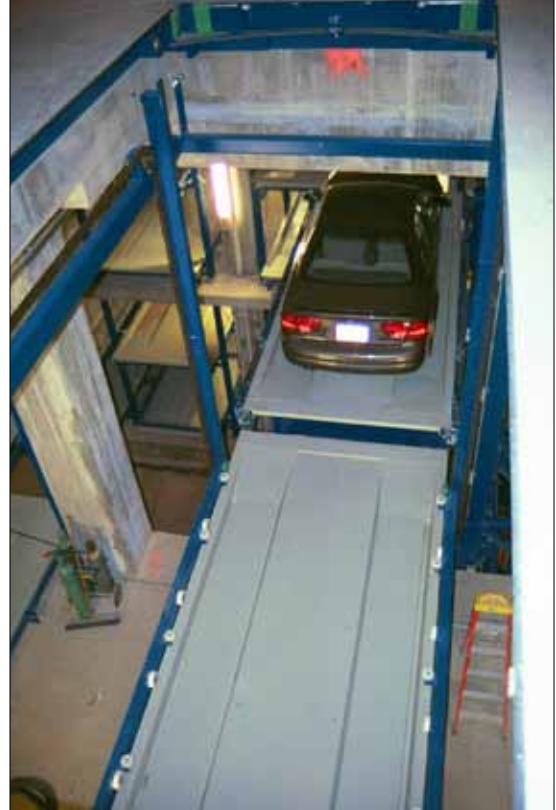
There are generally two types of AVSRS designs. One type consists of separate horizontal transport devices at each level and separate vertical lifts. A vehicle enters the transfer compartment and the patron vacates the stall and activates the storage process. A door opens on the side toward the storage vault and a motorized carrier slides under the vehicle and picks it up with arms that fold onto the wheels, or the car is on a pallet that is lifted slightly and removed from the compartment. The vehicle is then carried horizontally over to a lift platform and placed on the lift. The lift moves vertically to the desired storage level and the transport device carries the vehicle into the transport aisle and down to a storage space where it is deposited in a stall. The retrieval process works in the reverse order.

The second type is called a stacker crane, which is a motorized device that runs horizontally on rails on the ground floor with the lift mechanism built into the same piece of equipment. All vertical and horizontal movements are accomplished with this single device.

Because multiple transport devices can be accommodated with the former system, it has more redundancy and more throughput capacity than the stacker crane system.

AVSRS garages are gaining a lot of attention mainly because they accommodate the same number of parking spaces in half the space of conventional ramp-access, self-park garages. This results in faster construction, so the AVSRS garage can be placed into service faster and generate revenue sooner. When the AVSRS garage is located underground (as when under a building), the savings in underground construction cost and improved efficiency of the automated garage can often offset the cost of the automated parking machinery (see Table 2).

An AVSRS garage can also offer a high degree of convenience that's similar to automated valet parking. The vehicle is more secure in the unoccupied storage vault and less susceptible to damage, as it is parked by machines. Further, these garages can be built on sites



that are too small for conventional parking structures; they occupy a much smaller footprint and allow more site area for higher and better use.

## Cost

As Table 2 illustrates, the cost of an above-grade, ramp-access garage is generally less than that of an AVSRS garage, provided the site is large enough to design an above-grade, ramp-access garage at an efficiency of approximately 320 square feet per stall. As the garage efficiency approaches 450 square feet per stall—as is typical for a garage under a building—the cost of an AVSRS garage becomes much more competitive. If one is constructing a three- or four-level underground garage, it is possible with the increased efficiency of the AVSRS garage to save one or more levels. The lowest one or two levels of the underground garage are the most expensive, so the cost savings may be significant.

Note that the unit cost of the AVSRS building is slightly less than the conventional, ramp-access parking garage. This is because the AVSRS does not require mechanical

**Table 2: Construction Cost Comparison**

Configuration	Type	Unit Cost/ Sq. Ft.	Efficiency, Sq. Ft./Stall	Building Cost per Stall	AVSRS Cost	Total Cost per Stall
Stand-alone, above grade	Conventional	\$50	320	\$16,000	\$0	\$16,000
	Automated	\$45	225	\$10,125	\$16,000	\$26,125
Below building, above grade	Conventional	\$75	450	\$33,750	\$0	\$33,750
	Automated	\$65	225	\$14,625	\$16,000	\$30,625
Below building, below grade	Conventional	\$105	450	\$47,250	\$0	\$47,250
	Automated	\$85	225	\$19,125	\$16,000	\$35,125

**Table 3: Annual Operating Cost Per Space**

Item	AVSRS Garage	Ramp-Access Garage
Security	\$35	\$107
Management Fees	\$37	\$37
Supplies	\$19	\$19
Insurance	\$9	\$18
Utilities	\$45	\$52
Maintenance	\$400	\$67
Misc	\$10	\$10
Total	\$555	\$310

Disadvantages of AVSRS Garages	Advantages of AVSRS Garages
Higher construction cost than above-grade, stand-alone, efficient ramp-access garage.	Double the parking capacity in the same volume as a ramp-access garage.
Higher maintenance and operating cost than ramp-access garage.	Half the volume for the same capacity as a ramp-access garage.
Added cost to replace electrical components, computer hardware and software at the end of rated life.	Smaller footprint to enhance development opportunities.
	More secure, unoccupied storage vault.
	Less lighting, no ventilation of vehicle emissions, industrial stairs, no pedestrian elevators
	Enhanced user experience (automated valet parking)
	No attendants required.

ventilation as the vehicles are transported without their engines running. Also, minimal lighting is required in the unoccupied storage vault, less expensive industrial stairs can be provided, and pedestrian elevators are not required. Further, the height or depth of the AVSRS garage may be only 7 to 8 feet, compared to 10 to 11 feet for a conventional garage. Minimizing the depth is an important consideration in an underground garage where there are poor soil conditions and/or a high water table.

Operating cost is also an important consideration. Table 3 indicates the estimated operating cost per space for a minimum capacity parking structure of 200 cars with automated pay stations and no attendants.

The operating cost for the ramp access garage is based on Walker Parking Consultants' survey of more than 150 parking structures in 20 states with a median size of 720 spaces, from 2001 to 2005. The operating costs for the AVSRS garage are based on estimated adjustments from the conventional garage operating cost, except for the maintenance cost and electric utility cost, which were obtained from two different AVSRS suppliers.

The electrical components for the automated machinery and the computer hardware and software have limited life expectancies. As new technology is developed, the original installation becomes outdated. A maintenance contract could include updating the hardware, software, and electrical components as technology improves.

## Traffic Flow

The ability of the AVSRS garage to handle peak hour traffic flow is another consideration. The industry standard for maximum storage/retrieval time is 3.5 minutes from the entry/exit compartment to/from the farthest storage space. The number of transport devices and lifts must be sized to accommodate that requirement. The maximum storage/retrieval time for a four-level AVSRS garage with a capacity of up to 400 stalls with tandem parking is approximately 2.5 minutes. The average storage/retrieval time is less than two-thirds of the maximum time, resulting in an average service rate of 25 to 40 vehicles per hour per entry/exit compartment.

The number of entry/exit compartments should be sized so that the ratio of the two-way peak hour traffic volume to the aggregate average service rate of all entry/exit compartments is less than 0.7, to minimize vehicle queuing at each entry/exit.

## Reliability

Reliability of the AVSRS system is an important consideration. The AVSRS components include redundant devices to provide 99.96 percent reliability. If one motor is required to operate a transport device, two or more are provided. Multiple servers with backup emergency power are provided to improve reliability

of the computer system. The system can be monitored remotely via the internet with a manual override feature to remotely correct minor issues. The programmable logic controllers (PLC) are the brains of the system. Each PLC has 98 percent reliability. When paired with another PLC, the reliability improves to 99.96 percent. Those redundant components make the AVSRS system very reliable.

Is an AVSRS garage right for you? Only you know the answer to that. But there's no question that they are growing in popularity and becoming a viable option to consider. **P**

*Look for a case study on the City of West Hollywood, Calif.'s new automated garage in a future issue of The Parking Professional.*



**DON MONAHAN, P.E.,**  
is vice president  
of Walker Parking  
Consultants. He can  
be reached at  
[Don.Monahan@  
walkerparking.com](mailto:Don.Monahan@walkerparking.com) or  
303.694.6622.