

White Paper

Maximizing Storage Capacity



Introduction

Rare is the manufacturing, warehousing or distribution facility that does not suffer from some amount of space limitations. Sometimes inventory, parts or work-in-process have exceeded current capacity. Or perhaps the footprint of the facility prevents the addition of more storage equipment without an expensive addition of more floor space through construction. Either way, space is nearly always at a premium.

For facilities that rely on traditional shelving¹ – made of upright posts, formed steel sheet panels as horizontal shelves and end and back braces or sheet steel back and side panels for support – for storage of non-palletized loads, automated storage and retrieval systems (ASRS) are available as an alternative. These self-contained systems offer higher density storage in a more compact footprint than manual equipment can provide. Four primary types include:

Horizontal Carousel Module (HCM)

Consisting of carriers mounted on an oval track that rotate horizontally to deliver stored items to an operator. These automated storage and retrieval systems save up to 60% of floor space when compared to standard shelving and racking.

[Learn more about HCMs.](#)



Vertical Lift Module (VLM)

An enclosed automated storage and retrieval system that incorporates two columns of trays with a central extractor that automatically locates and retrieves stored trays from both columns, then presents them to the operator at a waist-high pick window. These systems save up to 85% of floor space compared to static shelving and racking.

[Learn more about VLMs.](#)



Vertical Buffer Module (VBM)

In the middle of a multi-segment shelving system is an aisle, where a moveable mast with a telescopic rotary gripper operates. The control unit sets the gripper in motion picking a bin and transporting it to a picking station.


[Learn more about VBMs.](#)



Vertical Carousel Module (VCM)

Comprised of a series of shelves that rotate around a track – similar to a Ferris wheel – these automated storage and retrieval systems quickly deliver stored items to an ergonomically positioned work counter at the operator's command. When compared to static shelving and racking, they save up to 75% of floor space.

[Learn more about VCMs.](#)

 [Learn more about the vertical storage solutions with our comprehensive Buyer's Guide.](#)

Benefits of ASRS

Each type of automated storage methodology offers different benefits in comparison to traditional, static shelving, including the amount of space/footprint required and ease of expansion, as shown in Table 1.

Table 1: Storage system comparison ranked by their benefits.
Ranking: 5 = best, 4 = great, 3 = better, 2 = good, 1 = fair

Benefits	Shelving	HCM	VCM	VLM	VBM
Space/Footprint	1	4	5	5	4
Expandability	5	4	3	4	3

Implementing one of the four types of high-density ASRS immediately reduces the amount of floor space required by shelving to store items. These space efficiencies can be further leveraged either through the storage of more products in the same amount of facility footprint, or via an expansion in the number of SKUs stored.



Storage capacity comparison

One way to compare automated storage and retrieval technologies to shelving is based on the available capacity within each system. A capacity comparison reveals how many sections of shelving fit into an ASRS, quantifying storage density within the unit.

To do these calculations, assumptions have to be made as to space utilization within the unit. Assumptions also have to be made about the size of the system. For the purposes of this white paper, common installation sizes were used to compare capacities. Before comparing shelving to the various automated technologies, we first must determine the capacity of a standard section of shelving.

Standard industrial shelving capacity

- Assuming 7 shelves per shelving section
- Unit specifications:
 $1\text{ m wide} \times 0.5\text{ m deep} \times 2.2\text{ m tall} = 1.1\text{ m}^3$ of storage space per shelving unit
- Assuming 30% utilization of shelving = 0.33 m^3 of storage space per shelving unit. Now we have determined each section of shelving provides 0.33 m^3 of storage space. We can compare this to the available capacity of each ASRS.

Horizontal Carousel Module capacity

- Carrier specifications = $825\text{ mm wide} \times 610\text{ mm deep} \times 2,159\text{ mm tall} = 1.09\text{ m}^3$ (cubic storage space per carrier)
- Number of carriers per HCM: 22
- $1.09\text{ m}^3 \times 22\text{ carriers} = 24\text{ m}^3$ (cubic storage space per unit)
- $24\text{ m}^3 \times 2\text{ HCMs} = 48\text{ m}^3$
- Assuming 62% utilization of HCMs = 29.75 m^3
- Two, 22 carrier HCMs provide 29.75 m^3 of storage capacity
- To calculate capacity savings in cubic meters: $29.75\text{ m}^3 / 0.33\text{ m}^3 = 90.15$

Calculation result: 90 sections of shelving fit into two, 22 carrier HCMs

Vertical Carousel Module capacity

- Carrier specifications = 3,050 mm wide × 626 mm deep × 331 mm tall = 0.63m³ (cubic storage space per carrier)
- Number of carriers per VCM: 26
- 0.63 m³ × 26 carriers = 16.38 m³ (cubic storage space per unit)
- Assuming 75% utilization of VCM = 12.28 m³
- One 5.8 m tall VCM provides 12.28 m³ of storage capacity
- To calculate capacity savings in cubic meters: 12.28 m³/0.33 m³ = 37.2

Calculation result: 37 sections of shelving fit into one 5.8 m tall VCM

Vertical Lift Module capacity

- Unit height = 7.5 m
- 325 mm tray spacing allows 36 trays for storage (front and back storage with room for access opening)
- Average product height per tray = 300 mm
- Tray dimensions = 3.050 mm wide × 813 mm deep × 300 mm tall = 0.74 m³ (cubic storage space per tray)
- 0.74 m³ × 36 trays = 26.64 m³ (storage space per unit)
- Assuming 75% utilization of VLM = 19.98 m³
- One 7.5 m tall Shuttle VLM provides 19.98 m³ of storage capacity
- To calculate capacity savings in cubic meters: 19.98 m³/0.33 m³ = 60.5

Calculation result: 60 Sections of shelving fit into one 7.5 m tall VLM

To further maximize cubic density, VLMs permit dynamic allocation of trays for variable increment storage heights inside the machine – rather than limiting each tray to a fixed height storage space. Equipped with an automated hardware and control system, the VLM incorporates a sensor which measures the height profile of each storage tray's contents as it passes onto the lift platform. The control system then determines the best storage location in the unit based on the least amount of space used within the fastest retrieval position. This function permits storage trays to be placed within 25 mm of each other, providing up to an additional 50 percent of storage capacity per unit. This technology has been factored into the capacity calculations above.



Vertical Carousel Module



Vertical Lift Module

Vertical Buffer Module capacity

- Unit height = 7 m
- Tote product storage dimensions = 600 mm length x 400 mm width x 320 mm height
- This Kardex Miniload-in-a-Box* unit can hold 538 totes of this size
- $600 \text{ mm} \times 400 \text{ mm} \times 320 \text{ mm} = 0.077 \text{ m}^3$
- $0.077 \text{ m}^3 \times 538 \text{ totes} = 41.4 \text{ m}^3$ (storage space per unit)
- Assuming 75% utilization of VBM = 31 m^3
- One 7 m tall Kardex Miniload-in-a-Box (VBM) provides 31 m^3 of storage capacity
- To calculate capacity savings in cubic meters: $31 \text{ m}^3 / 0.33 \text{ m}^3 = 93.9$

Calculation result: 93 sections of shelving fit into one 7 m tall VBM



Kardex VBM Box

* formerly Kardex Compact Buffer



Floor space savings comparison

Another way to compare these technologies is based on floor space, measured in square meters. As a general rule of thumb, when compared to standard shelving, HCMs save up to 60 percent of floor space, VCMs save up to 75 percent of floor space, VLMs save up to 85 percent of floor space and VBM save up to 80 percent of floor space.

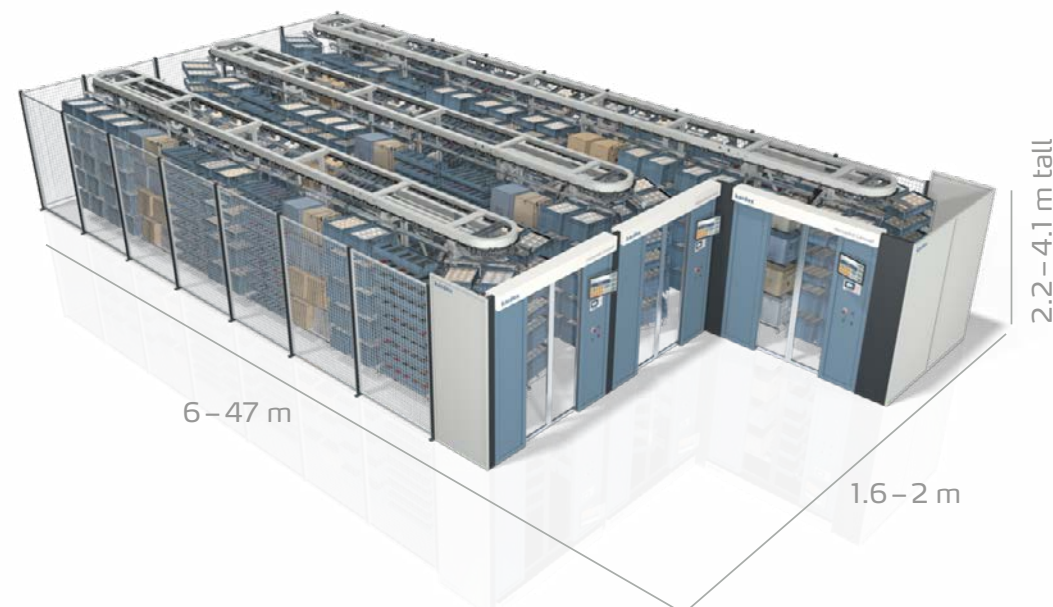
As with capacity, when comparing floor space savings, certain assumptions need to be made, such as aisle space and access space. For purposes of these calculations, 1.2 meters of aisle space and 1.25 meters of access (or turnaround) space have been assumed.

HCM floor space savings

To determine the equivalent capacity of standard shelving to a HCM, first determine how many shelves of inventory can fit into a typical machine (approximately 2.6 meters tall). Assumptions are included within the calculations, which also take into account the width of standard access aisles required for access to the storage medium.

Horizontal Carousel Module

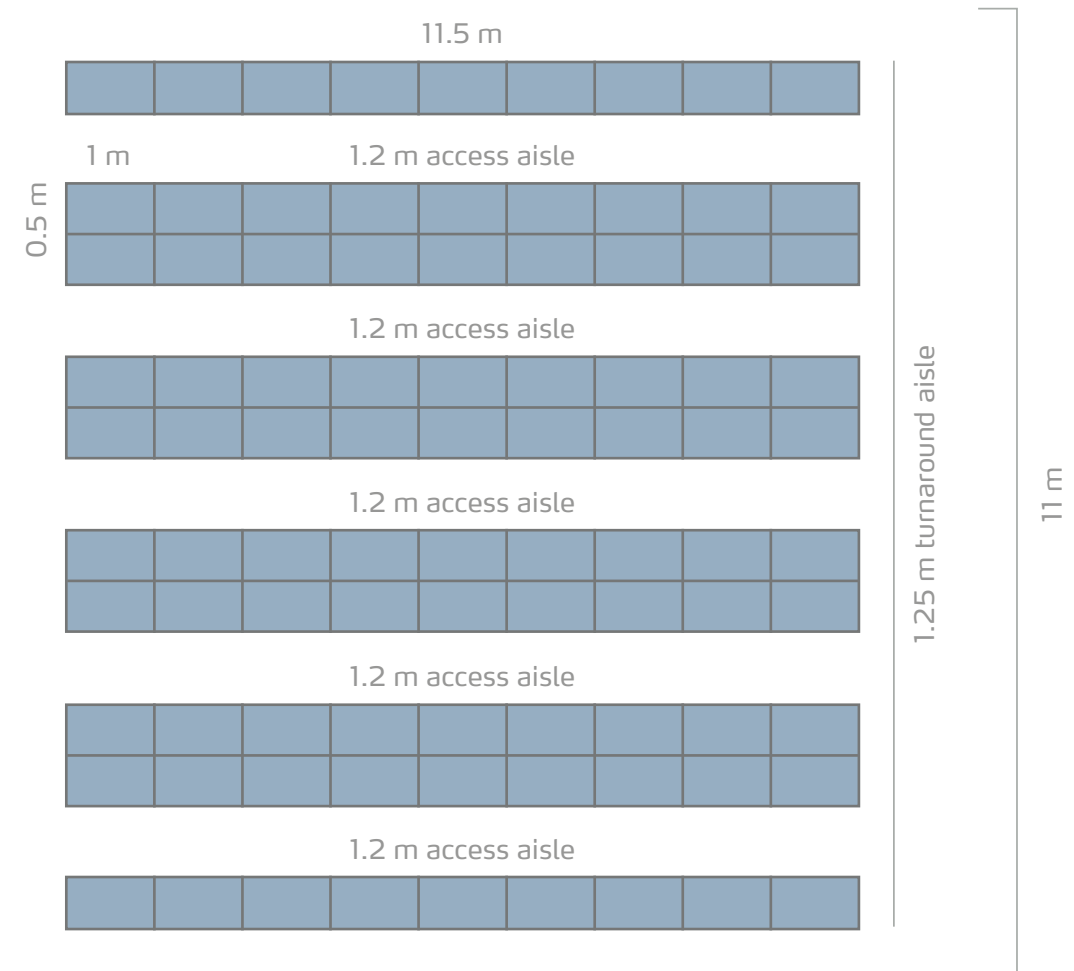
- Unit width: 2 m × 2 carousels = 4 m, plus 300 mm space between carousels and 150 mm on each side = 4.6 m
- Length (22 carrier unit): 11.5 m plus 1.25 m access = 12.75 m
- Horizontal Carousel Module floor space occupied: 4.6 m wide × 12.75 m long = 58.65 m²



90 shelving sections

- Width: 1 m with 1.25 m turnaround
- Depth: 0.5 m with 1.2 m aisle access
- Width: (1 m wide × 9 bays) + (2 × 1.25 m aisle) = 11.5 m wide
- Depth: (0.5 m deep × 10 sections) + (5 × 1.2 m aisle) = 11 m deep
- Shelving floor space occupied: 11.5 m × 11 m = 126.5 m²
- To calculate floor space savings in square meters:
 $126.5 \text{ m}^2 - 58.65 \text{ m}^2 = 67.85 \text{ m}^2 / 126.5 \text{ m}^2 = 0.54$

Calculation result: In this example, Horizontal Carousel Modules save 54% floor space!



VCM floor space savings

To determine the equivalent capacity of standard shelving to a VCM, first determine how many shelves of inventory can fit into a typical unit.

Vertical Carousel Module

- Unit specifications: 3.67 m wide x (1.67 m deep + 1.5 m access area = 3.17 m) = 11.61 m²

36 shelving sections

- Width: 1 m with 1.25 m turnaround
- Depth: 0.5 m with 1.2 m aisle access
- (1 m wide x 6 bays) + (2 x 1.25 m aisle) = 8.5 m wide
- (0.5 m deep x 6 sections) + (3 x 1.2 m aisle) = 6.6 m wide
- Shelving floor space required: 8.5 m x 6.6 m = 56.1 m²
- To calculate floor space savings in square meters:
56.1 m² - 11.63 m² = 44.5 m²/56.1 m² = 0.79

Calculation result: In this example, Vertical Carousel Modules save 79% floor space!



Combining floor space savings with capacity savings

Further, applying the capacity numbers from above can determine how much additional cube is provided. It was determined that each section of shelving provided 0.33 m³ of capacity, while each VCM carrier provided 0.63 m³ of capacity.

- 0.33 m³ per shelving section x 36 shelving sections = 11.88 m³ of storage capacity
- 0.63 m³ per vertical carousel carrier x 26 carriers = 16.38 m³ of storage capacity
- To calculate additional capacity in cubic meter: 16.38 m³ - 11.88 m³ = 4.5/16.38 = 0.27

Not only can Vertical Carousel Modules typically save 75% floor space, they provide approximately 25% additional capacity.



VLM floor space savings

To determine the equivalent capacity of standard shelving to a VLM, first determine how many shelves of inventory can fit into a typical VLM (approximately 7.5 m tall).

Vertical Lift Module

- Unit specifications:
 $3.38 \text{ m wide} \times (2.9 \text{ m deep} + 1.2 \text{ m access area} = 4.1 \text{ m deep}) = 13.85 \text{ m}^2$

60 shelving sections

- Width: 1 m with 1.25 m turnaround
- Depth: 0.5 m with 1.2 m aisle access
- $(1 \text{ m} \times 6 \text{ sections}) + (2 \times 1.25 \text{ m access aisle}) = 8.5 \text{ m wide}$
- $(0.5 \text{ m} \times 10 \text{ sections}) + (5 \times 1.2 \text{ m aisle}) = 11 \text{ m deep}$
- Shelving floor space required: $11 \text{ m} \times 8.5 \text{ m} = 93.5 \text{ m}^2$
- To calculate floor space savings in square meters:
 $93.5 \text{ m}^2 - 13.85 \text{ m}^2 = 79.65 \text{ m}^2 / 93.5 \text{ m}^2 = 0.85$

Calculation result: In this example, Vertical Lift Modules save 85% floor space!



Combining floor space savings with capacity savings

Further, applying the capacity numbers from above can determine how much additional cube is provided. It was determined that each section of shelving provided 0.33 m^3 of capacity, while each VLM tray provided 0.74 m^3 of capacity.

- $0.33 \text{ m}^3 \text{ per shelving section} \times 60 \text{ shelving sections} = 19.8 \text{ m}^3 \text{ of storage capacity}$
- $0.74 \text{ m}^3 \text{ per VLM tray} \times 36 \text{ trays} = 26.64 \text{ m}^3 \text{ of storage capacity}$
- To calculate additional capacity in cubic meters: $26.64 \text{ m}^3 - 19.8 \text{ m}^3 = 6.84 / 26.64 = 0.25$

Not only can Vertical Lift Modules save 85% floor space, they provide approximately 25% additional capacity.



VBM floor space savings

To determine the equivalent capacity of standard shelving to a VBM, first determine how many shelves of inventory can fit into a typical unit (Approximately 7 m tall).

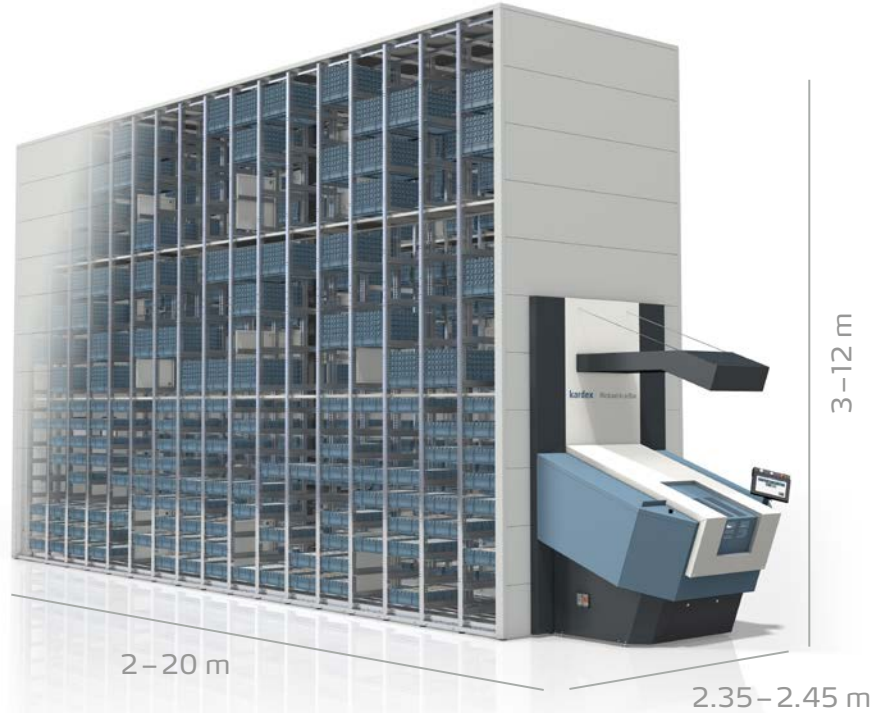
Vertical Buffer Module

- Unit width: 2.35 m, plus 0.05 m clear = 2.4 m
- Unit length = 11.1 m + 1.2 m pick area + 1.2 m maintenance = 13.5 m
- Vertical Buffer Module floor space occupied: 2.4 m wide × 13.5 m long = 32.4 m²

90 shelving sections

- Width: 1 m with 1.25 m turnaround
- Depth: 0.5 m with 1.2 m aisle access
- Width: (1 m wide × 9 bays) + (2 × 1.25 m aisle) = 11.5 m wide
- Depth: (0.5 m deep × 10 sections) + (5 × 1.2 m aisle) = 11 m deep
- Shelving floor space occupied: 11.5 m × 11 m = 126.5 m²
- To calculate floor space savings in square meters:
 $126.5 \text{ m}^2 - 32.4 \text{ m}^2 = 94.1 \text{ m}^2 / 126.5 \text{ m}^2 = 0.74$

Calculation result: In this example, Vertical Buffer Modules save 74% floor space!





Space savings in action: Kubota

OEM parts supplier saves 71% floor space with Horizontal Carousel Modules; 83% floor space with VLMs

With a commitment to keeping replacement parts available for 20-plus years to support their full line of tractor and utility vehicles, Kubota Canada Ltd.'s Markham, Ontario distribution center was challenged to store more than 78,000 SKUs in a 5,574 m² facility. In order to maximize storage density in a minimum footprint, the company implemented automated storage and retrieval technologies in phases.

In the first phase, Kubota purchased six Horizontal Carousel Modules from Kardex to replace a three-story mezzanine that occupied 278 m² per floor (836 m² of inventory storage total). Including a workstation, picking area and six, 7.31 m-long HCMs the system occupies 241 m² – 71 percent less floor space than the mezzanine. Additionally, all the parts are now stored on a single floor, enabling a single operator to pick parts ergonomically and more than 90 percent faster without walking up and down stairs.

Instead of considering a building expansion, the company installed Vertical Lift Modules from Kardex as part of the second phase of the picking system implementation. The first two Kardex Shuttle replaced 222 m² of 5.4 m-high bay shelving. Shortly thereafter, two more VLMs were installed to replace 111 m² of 5.4 m-high bay shelving. In this zone, the workstation, picking area and four Kardex Shuttle now occupy 57 m² allowing Kubota to free up just under 278 m² of floor space for an increase in parts capacity – and 83 percent floor space savings. In addition to increased part capacity and improved ergonomics, picking productivity in the VLM zone has doubled simply by eliminating travel time to part locations.

The investment in automated storage and retrieval systems has enabled the facility to accommodate 70 percent growth over the past 12 years with minimal increases to its labor force. Further, the current ASRS has enough remaining capacity to allow the facility to sustain this rate of growth for an additional five to eight years.

About Kardex

Kardex is a leading intralogistics solution provider of automated storage, retrieval, and material handling systems in an attractive and growing market. With two entrepreneurially managed divisions, Kardex Remstar and Kardex Mlog, as well as Corporate Ventures (Rocket Solution, SumoBox, Kardex AutoStore Solutions) offering complimentary cutting-edge technology, Kardex developed into a global industry partner.

Kardex Remstar is a global market leader for dynamic storage, retrieval, and material handling solutions. Kardex Mlog has a leading position in Central Europe for stacker cranes, conveyor systems, and automated material handling systems. The two divisions are unified under a strong group brand. With over 140,000 installations Kardex has a broad existing customer base that counts on first-class after-sales services.



Contact a specialist

Bibliographical references

- ¹. Material Handling Industry, "Glossary>Shelving," accessed June 19, 2019, <http://mhia.org/learning/glossary/s#shelving>.