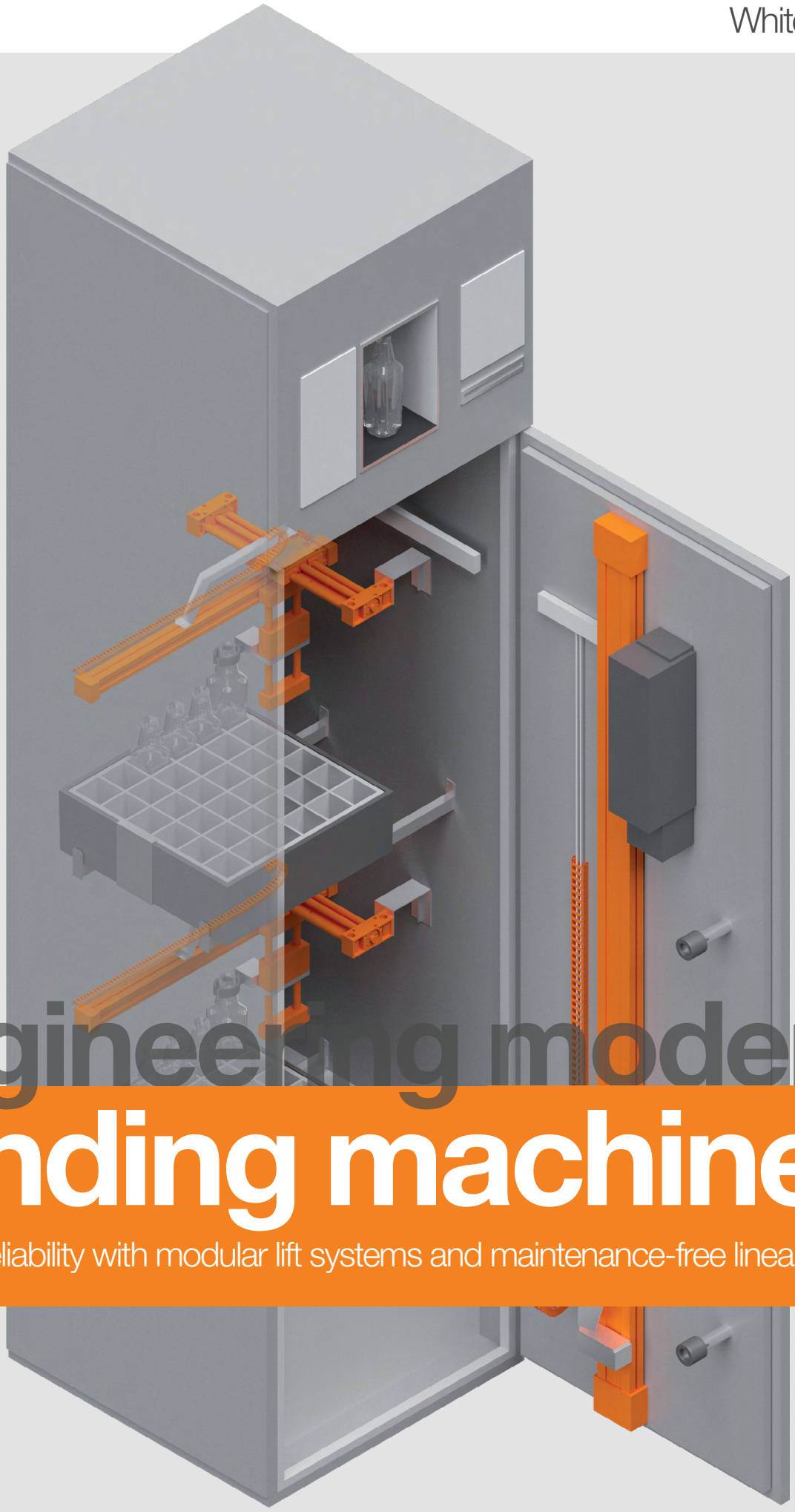


Engineering modern vending machines

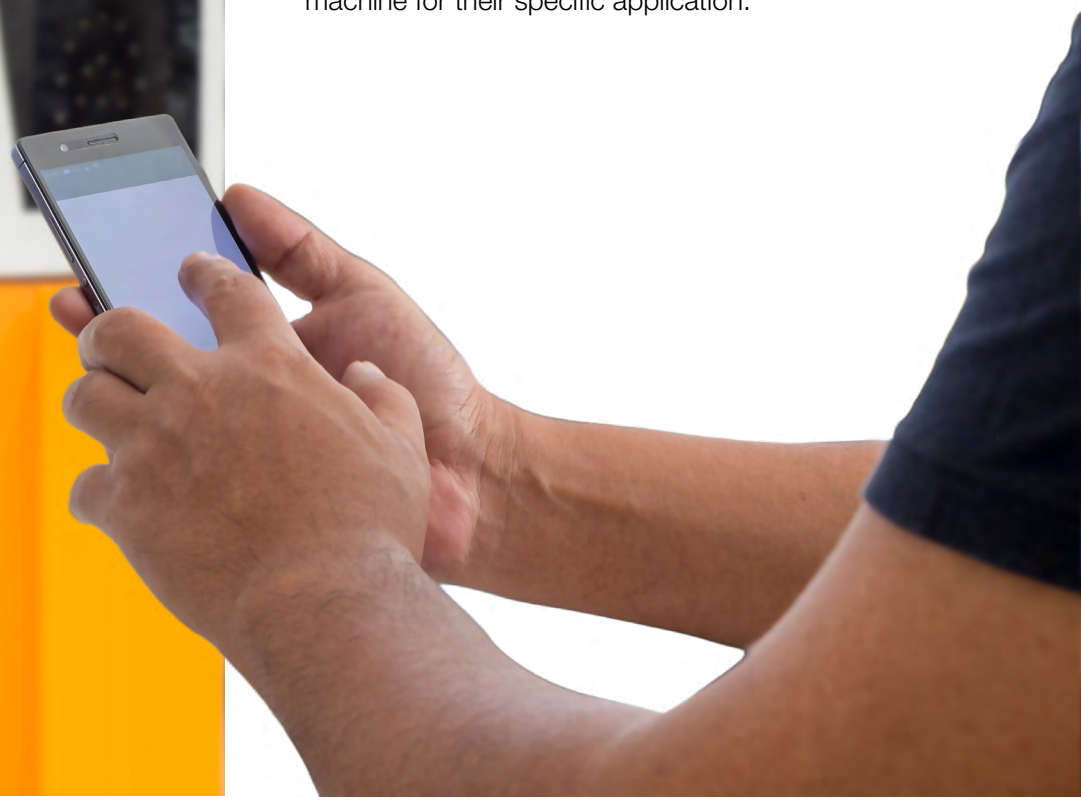
Improving reliability with modular lift systems and maintenance-free linear robots

Introduction & background

Vending machines have become increasingly popular in recent years. The vending industry was worth around $20.1 billion in the United States alone in 2023[1], and there are about 15 million vending machines in use worldwide[2].

Vending machine manufacturers need to determine how the products are stored, presented, and made available to the buyer — and how the mechanical components of the movable product dispenser are designed. One option is the use of lift systems in combination with preconfigured gantry robots. However, completely different design concepts are possible as well.

This white paper will show off some of the possibilities in vending machine design, and explain what designers should consider when planning the optimal vending machine for their specific application.



1 https://market.us/report/vending-machine-market/

2 https://www.globenewswire.com/news-release/2020/03/25/2006076/0/en/Global-Connected-Vending-Machines-Market-Report-2019-to-2024-4th-Edition.html

Attractive growth market

According to market analyses, the vending market will continue to grow, especially in public spaces. This is for a few reasons:

- Mobility will continue to increase
- “Food to go” is part of everyday life
- Acceptance of vending machines is growing
- Cashless and contactless payment of small amounts of money

In addition, vending machines are already more widespread in other industrialized nations — Japan, for instance. In Germany, there is one vending machine for every 130 inhabitants; in the U.S., one per every 66 people; and in Japan, one per roughly 25 people. Vending machines in Japan compete with “konbini” (mini supermarkets open 24/7), making this figure all the more impressive. This also speaks in favor of further growth for vending machines in the U.S. and Germany.

Other trends, like vending machines stocking a wider range of products — cosmetics, nutritional supplements, or even footwear — are further improving the reception of vending machines. They are also increasingly being used for direct sales, for example by farm shops and for around-the-clock supply of specialty items at the point of use, including worm bait at fishing spots.

Four designs

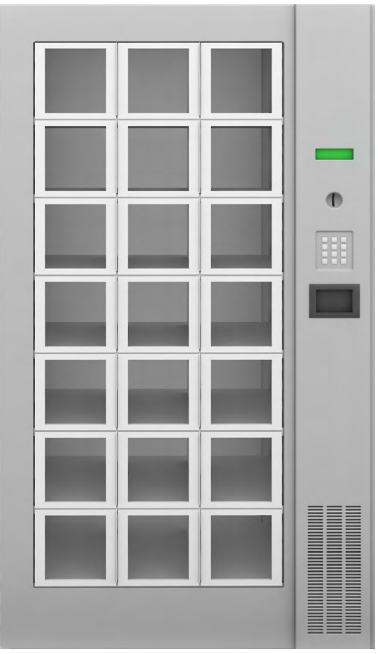
flap, spiral, drum & lift system

Vending machines require attractive presentation and flawless handling of the sales process, including goods dispensing. The inner workings of the vending machines, especially the dispensing mechanism, must be optimally designed and function flawlessly. This applies to all common machine designs, each of which places different demands on the drive and handling technology.

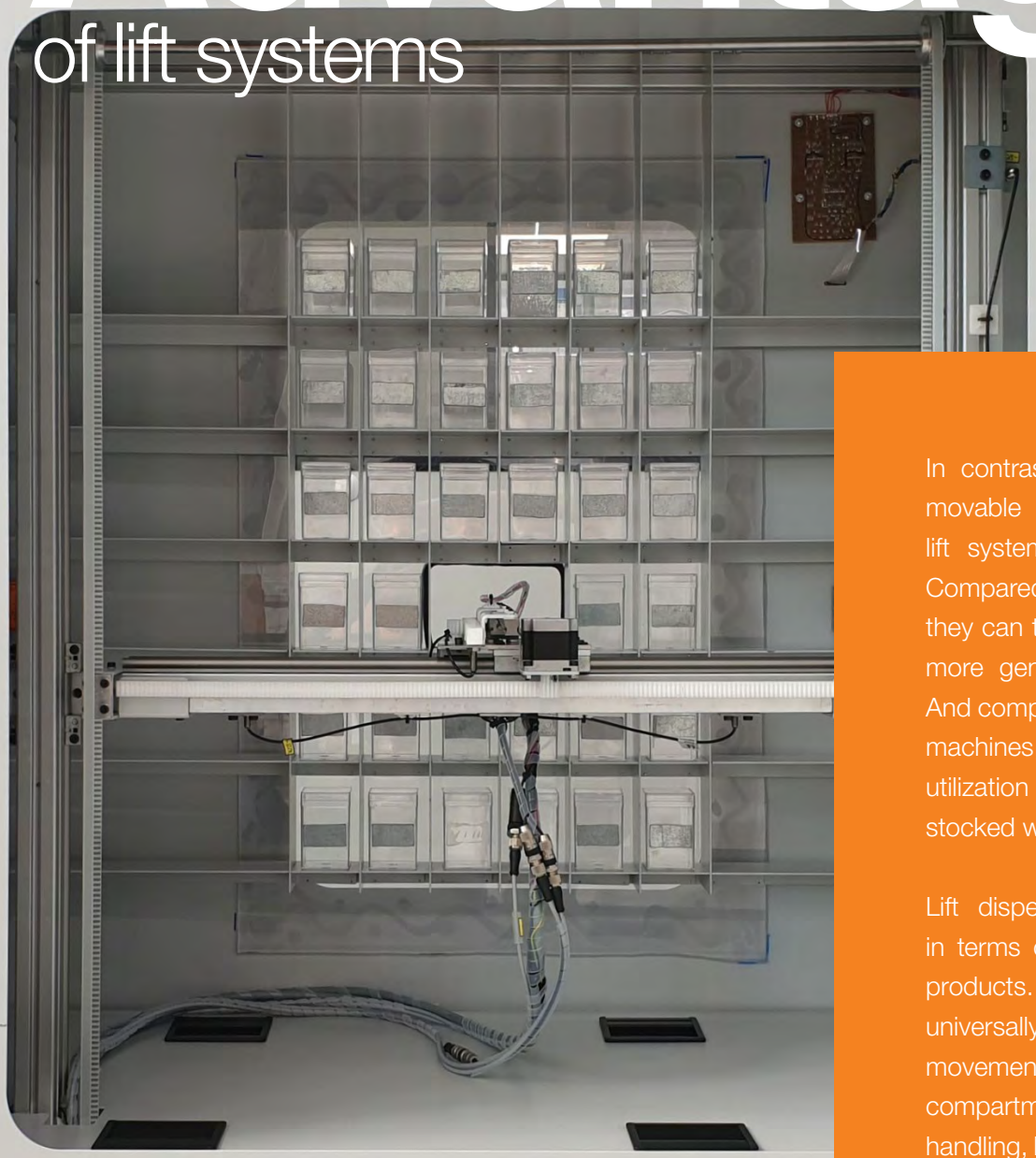
As diverse as the range and appearance of vending and food service machines may be, they are almost always implemented in one of four designs: flap, spiral, drum, and lift.

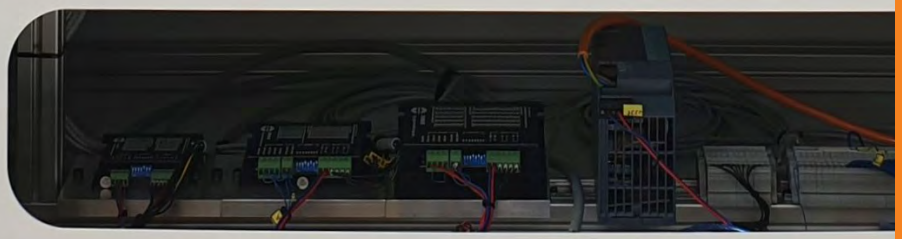
- Flap vending machines have numerous flaps, each of which opens a compartment containing a product.
- Spiral or chute machines place goods within a metal spiral. The product the customer requests is dispensed by moving the spiral by motor, and the product falls into a dispensing chute.
- In drum machines, the individual levels are implemented in cylindrical form. When a chamber opens and the customer removes a product, the drum with the empty compartment rotates to the back of the machine, and a full chamber moves to the front. The customer also has the option of rotating the drum by pressing a button to access the desired compartment.
- In lift machines, a carriage travels up to the compartment where the product is stored. The article is transferred to the carriage, which moves to a dispensing compartment where the customer can remove the product.

Flap, spiral, drum and lift are the most common machine types.
Source: igus



Advantages of lift systems

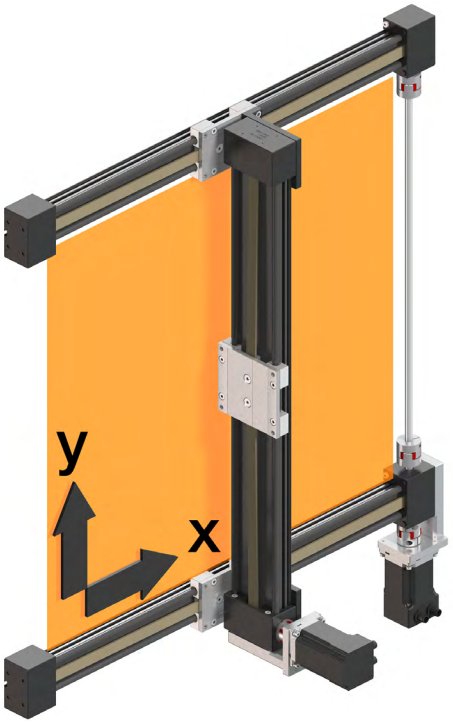




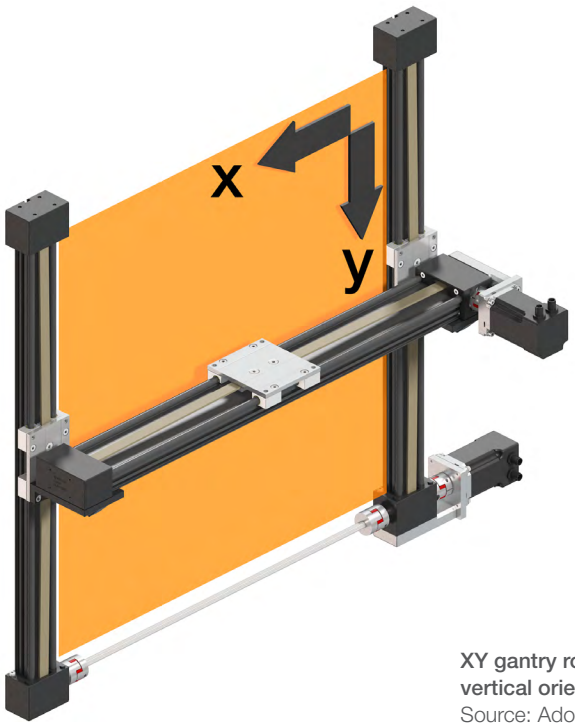
In contrast to the other designs with movable components shown above, lift systems offer several advantages. Compared to spiral vending machines, they can transport the products for sale more gently to the dispensing chute. And compared to drum and flap vending machines, they enable better space utilization allowing the machine to be stocked with more product.

Lift dispensers are also very flexible in terms of the size and nature of the products. They can therefore be used universally. What's more, the visible movement of the gantry in front of the compartments not only ensures gentle handling, but also creates a certain "wow effect" for the customer, who can follow the product preparation process at close range and in full view.

Lift machine with igus® drylin® linear robot
Source: igus



XY gantry robot with a horizontal orientation
Source: Adobe stock

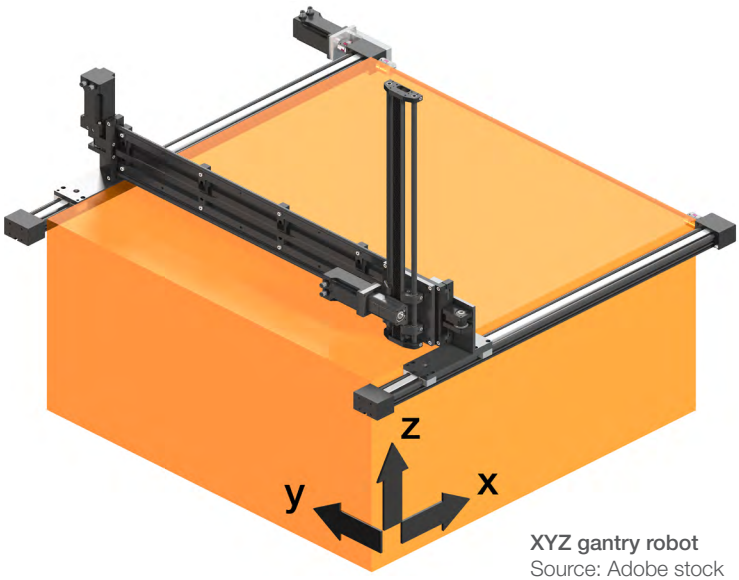


XY gantry robot with a vertical orientation
Source: Adobe stock

Gantry designs
for lift machines

A lift machine designer has three gantry robot designs to choose from:

- With an XY gantry robot with horizontal orientation, the y-axis moves between two horizontal x-axes and moves the desired plane or the target compartment.
- For vertically oriented XY gantries, the reverse is true: the Y-axis moves between the vertical X-axes.
- XYZ gantry robots can also be used for three-dimensional motion sequences. This means that a gripper can actively move into the target compartment and remove the product.



XYZ gantry robot
Source: Adobe stock

Requirements for drive technology

Regardless of which type of gantry is used, special requirements apply to the moving components of vending machines:

High availability

The gantries must function reliably in 24/7 operation. Service technicians are not nearby and have to travel to the vending machine for maintenance. This results in extended downtime, higher costs, and lower sales

Low maintenance

Vending machines are sometimes located in extremely remote places. This makes them difficult to access. In such cases, maintenance intervals are associated with higher costs.

Comfort

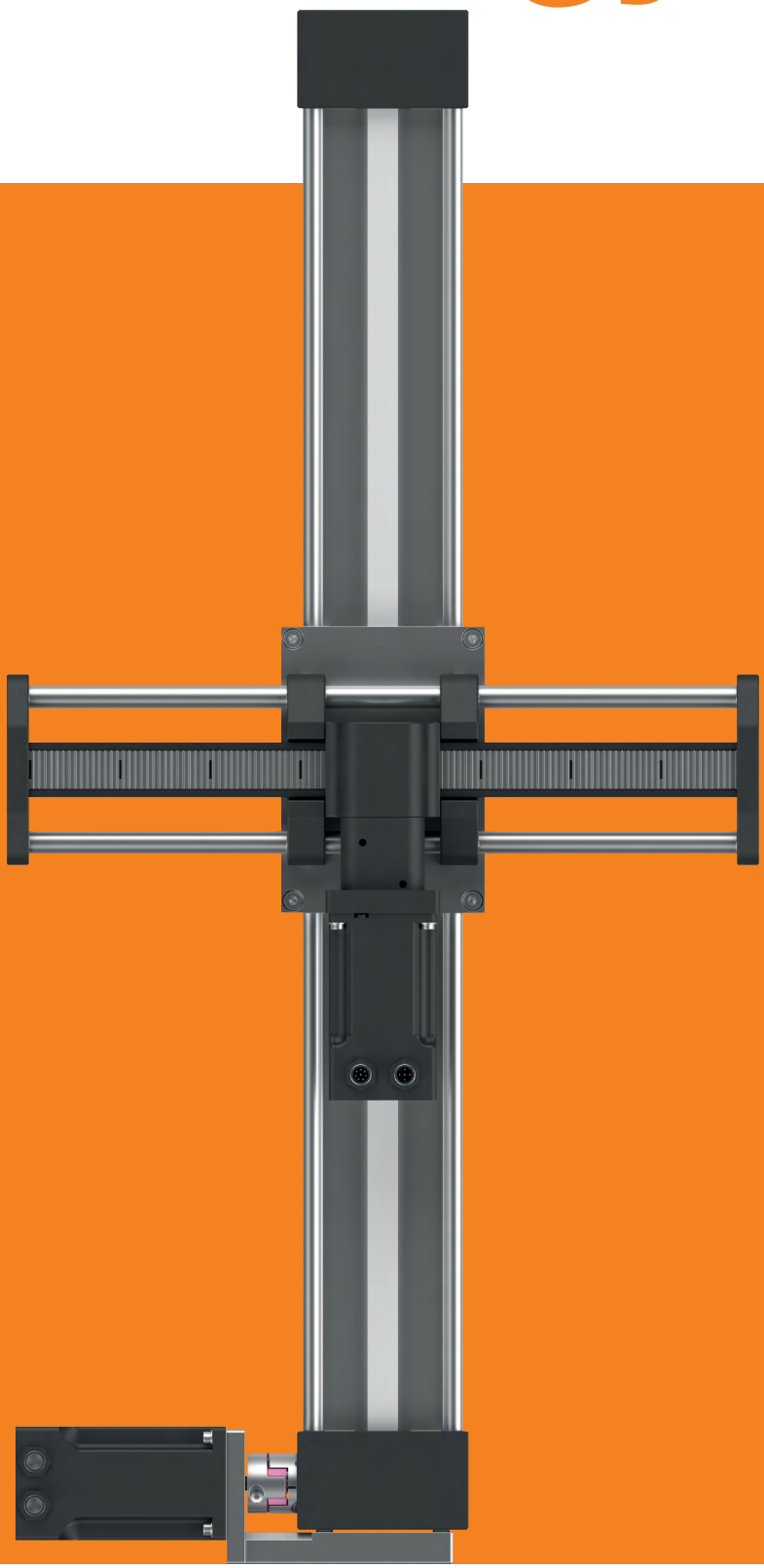
Low-vibration and quiet operation is desirable.

Broad temperature range

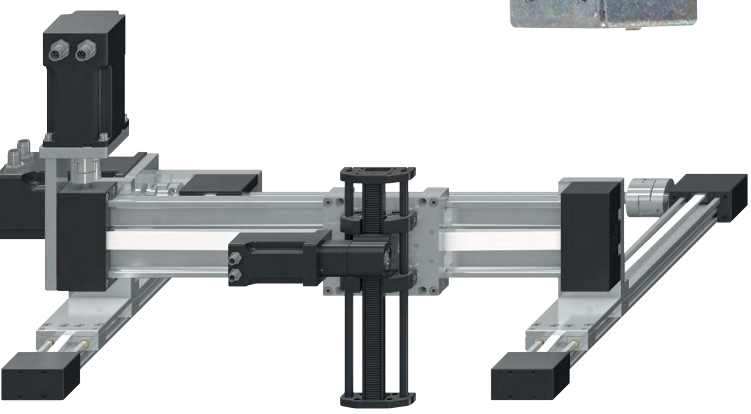
Many vending machines provide refrigerated products, and vending machines in public areas are exposed to natural temperature fluctuations.

Favorable costs

The vending market is very price-sensitive and a short ROI is expected.



Gantry robot systems
vending machinery



Quiet and space-saving drylin linear systems, also with motor.
Source: igus

igus offers manufacturers of vending machines a product range of gantry robots that precisely fulfill these requirements. igus gantries are tried and tested in industrial applications, where they are often subjected to much greater stress than in vending machines.

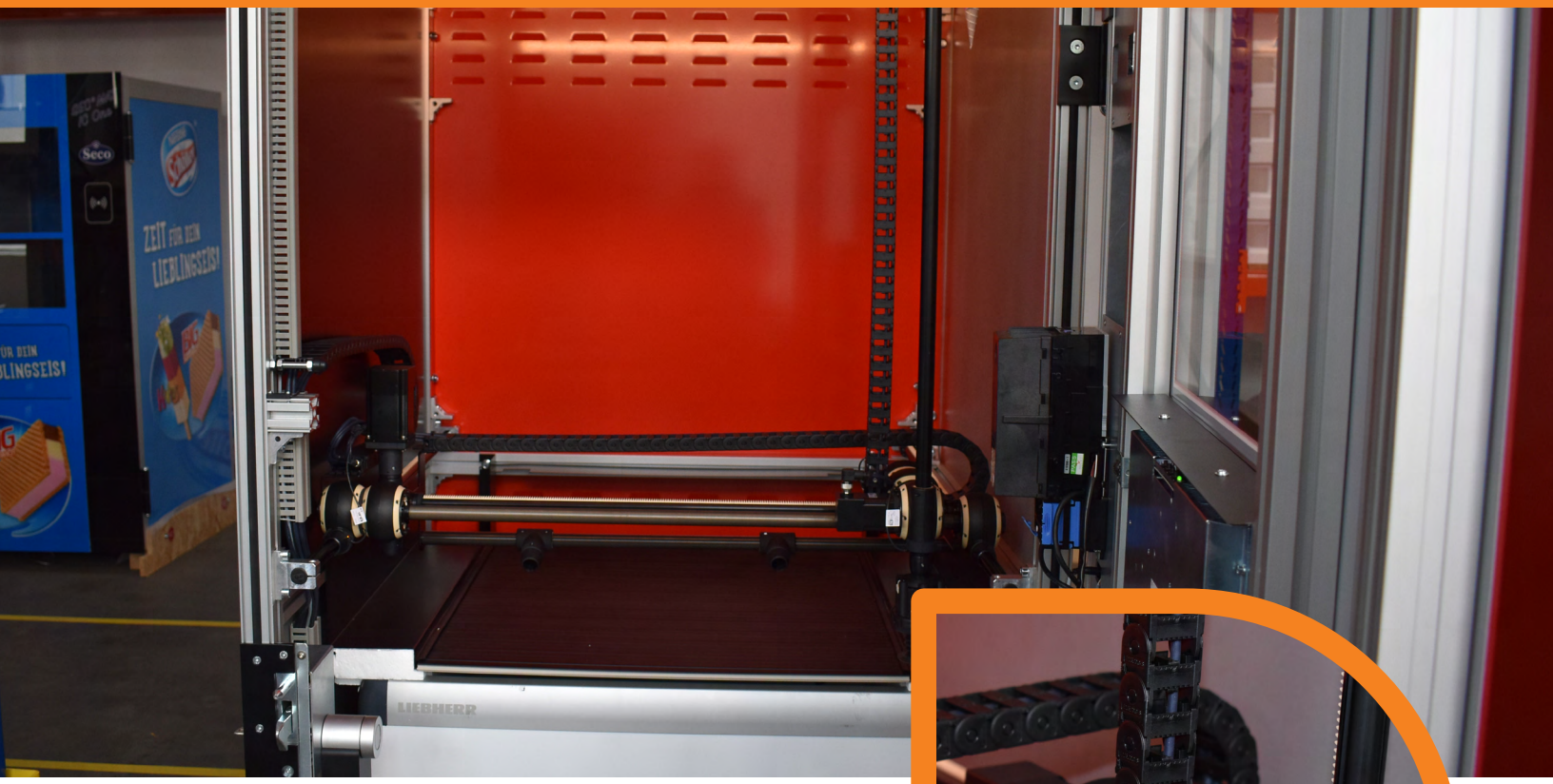
High-performance plastics with incorporated lubricant enable grease-free operation, which prevents the product from coming into contact with lubricant. The axes, which are driven by toothed belts, are also characterized by smooth, low vibration and quiet operation.

igus XY gantries by the numbers

- Load capacity up to 150N
- Repeatability approx. +/- 0.5mm
- Speeds up to 1m/s
- Acceleration up to 2m/s2

igus XYZ gantries by the numbers

- Load capacity up to 100N
- Repeatability approx. +/- 0.5mm
- Speeds up to 1m/s
- Acceleration up to 2m/s2



Apiro linear robot in the dispensing mechanism of an ice cream vending machine

It's up to the designer

A lift system designer can use the igus design kit without committing themself to a specific technology. This is because, in addition to the gantry robot systems with toothed belt drives, igus offers other linear axis systems that can be combined to form gantry robots.

- In drylin lead screw linear actuators, linear adjustment is handled by trapezoidal or high helix lead screws. The length of the stroke can be freely selected, and lead screws with plain bearings or ball bearings are available.
- Rack and pinion actuators are also available, offering high rigidity and precision in any installation position. Rack and pinion drives allow optimal use of installation space, so that both the vending machine manufacturer and the operator can accommodate more saleable products in the same space
- The Apiro® gearbox kit enables designers to implement gantry robots that are both cost-effective and precise. Lift systems (in addition to lane adjusters, pushers, etc.) are a good use case for this system, to perform such movements as pick-and-place movements. The modular Apiro gearbox kit offers limitless development options.

Which drive is best?

Toothed belt, lead screw, rack and pinion — as with other applications, there is no one linear system that is best for automatic lifts. The deciding factors are the use case and the property deemed most important in a given project.

If compactness is most important, gear racks are likely the best choice. If it is speed, the toothed belt is best. For positioning accuracy, the lead screw drive is the most obvious solution.

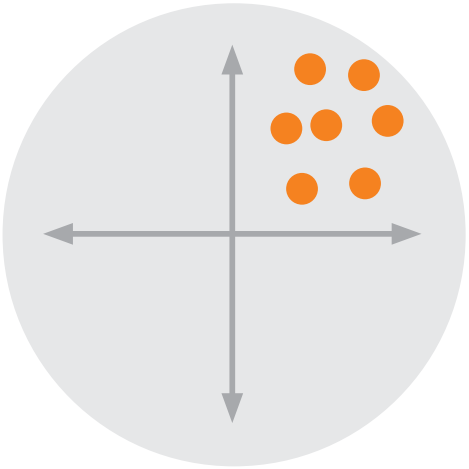
Tips for optimizing repeatability

A deciding factor in the flawless function of vending machines in the long-term is gantry repeatability. This accuracy depends on many factors that the designer should take into account.

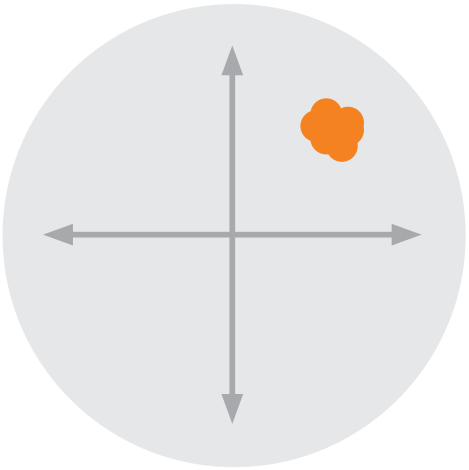
All actuator and gantry components (motor, gearbox, coupling, etc.) can have clearance, which adds up accordingly. The designer should use components with as little clearance as possible and keep the number of drive train or guide system components down.

All linear elements (linear drive, guides, housing frame, etc.) can also warp, bend, or twist, impairing positioning and repeat accuracy.

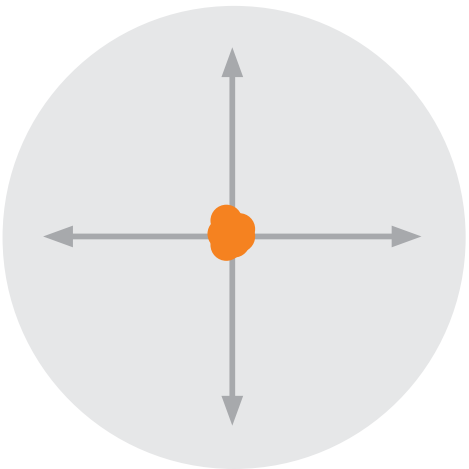
Installation accuracy is important (no misalignment with axes moving in parallel), as is connection element selection (screw locking device).



Low positioning accuracy; low repeatability



Low positioning accuracy; high repeatability



High positioning accuracy; high repeatability

Source: igus

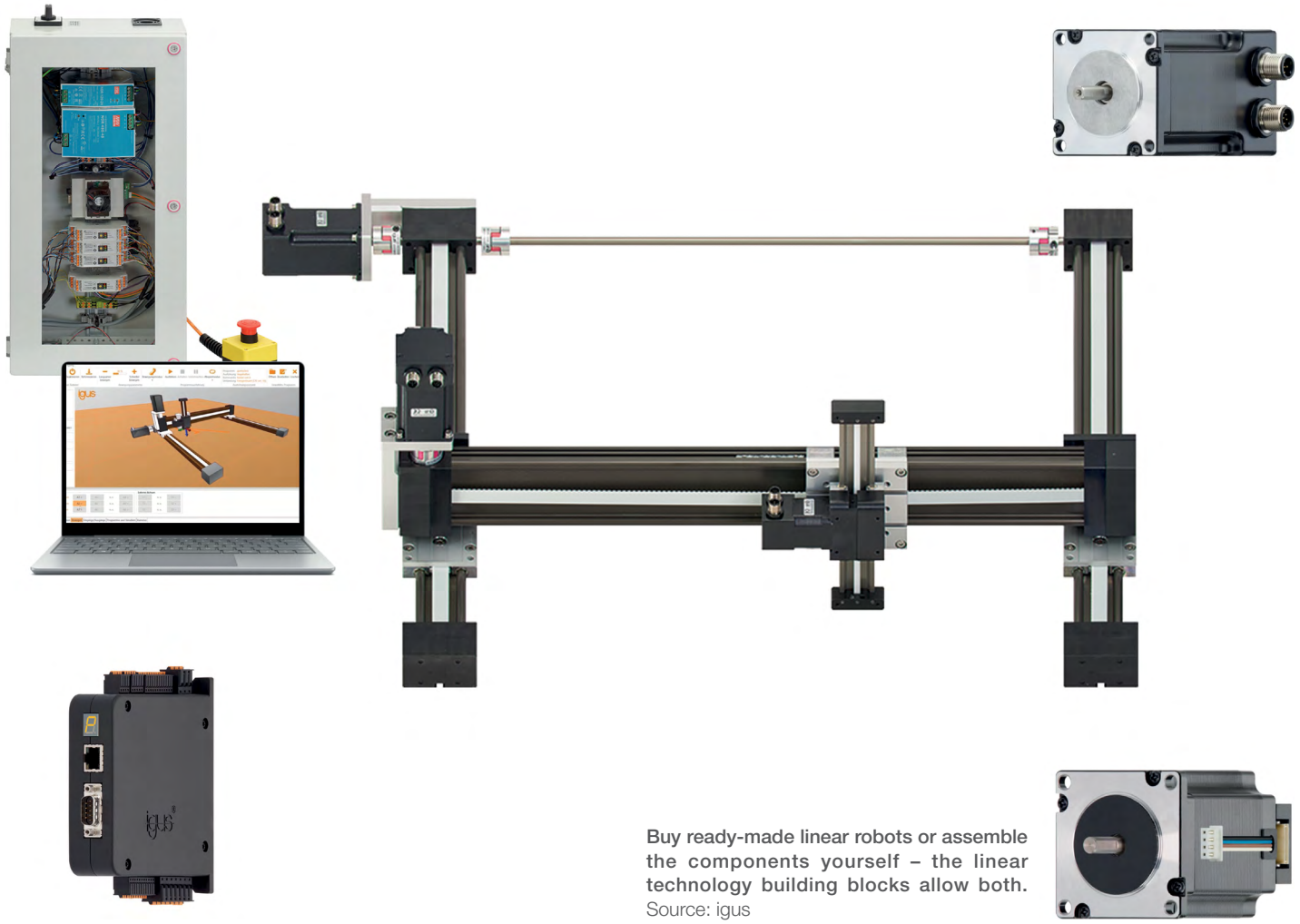
Build or Buy

Retail is not the only place where business models are changing (and increasing the vending machine market share). New forms of collaboration are also gaining ground in B2B mechanical engineering.

For the vending machine manufacturer working with igus, this means that they do not necessarily have to select and order the individual components and assemble and install them in their own production facility. They can also configure a complete gantry robot online, starting with a standard robot that can be customized to meet individual application requirements.

Because gantry robots are modular, they can be flexibly dimensioned and configured. They are thus a cost-effective complete solution for direct installation — because despite the individual configuration, they are no more expensive than standard gantries.

The configuration options include not only the pure axes, but also the complete peripherals including cables, motors, and even control systems. Here, in control technology, igus offers its own product range specially tailored to the requirements of linear technology.

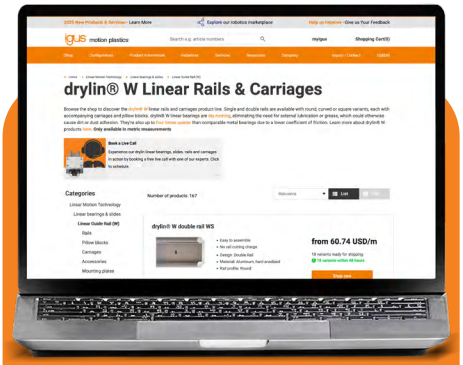


Buy ready-made linear robots or assemble the components yourself – the linear technology building blocks allow both. Source: igus

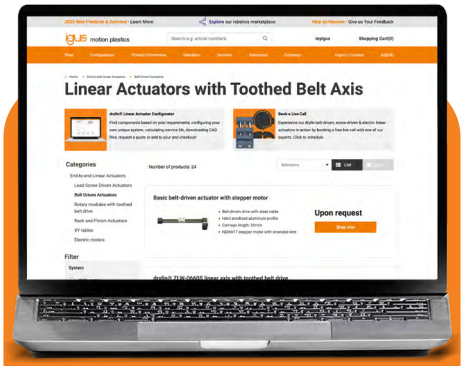
The question of core competence

Complete gantry modules can be manufactured and shipped on a rack upon special request. On site, they only need to be installed and connected as a module. And if it ends up being a self-built solution, igus offers all the necessary components from batch size 1 for development. The customer receives the individual axes and has to assemble them into a system.

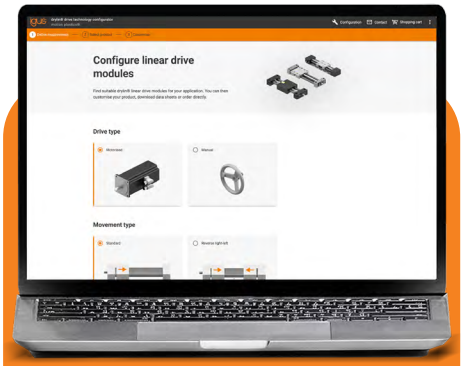
Ultimately, the vending machine manufacturer must ask: What is my core competence? Does the focus lie in the assembly of linear systems for gantry robots, or in the construction of innovative vending machines that inspire vending machine manufacturers, operators, and end customers alike?



view the **drylin linear rails shop** here



view the **drylin actuator shop** here



view the **linear actuator configurator tool** here

Don’t forget peripherals!

When purchasing complete modules, the vending machine manufacturer should not lose sight of individual components. After all, moving components are used not only in the lift system’s gantry, but also in other places in the machine. Here, a design that uses the igus building blocks is a good way to go. For example, moving cables are often a critical factor in vending machine service life. With igus energy chains, manufacturers and operators are on the same side.

e-chain E2 micro and chainflex cables CF140UL and CF130UL
Source: igus

Conclusion

As the global vending landscape evolves from simple snack dispensing to sophisticated, 24/7 automated retail, the engineering behind these machines must advance to meet higher consumer expectations. While traditional mechanisms remain useful, lift systems powered by robust gantry robots offer distinct advantages in space utilization, gentle product handling, and visual appeal. By leveraging modular, maintenance-free solutions—such as the grease-free plastics and flexible drive technologies offered by igus—manufacturers can streamline their production through a strategic “build or buy” approach. Ultimately, selecting the right combination of reliable components and drive technology empowers designers to focus on innovation, ensuring their machines are durable, cost-effective, and ready to capitalize on this rapidly growing market.