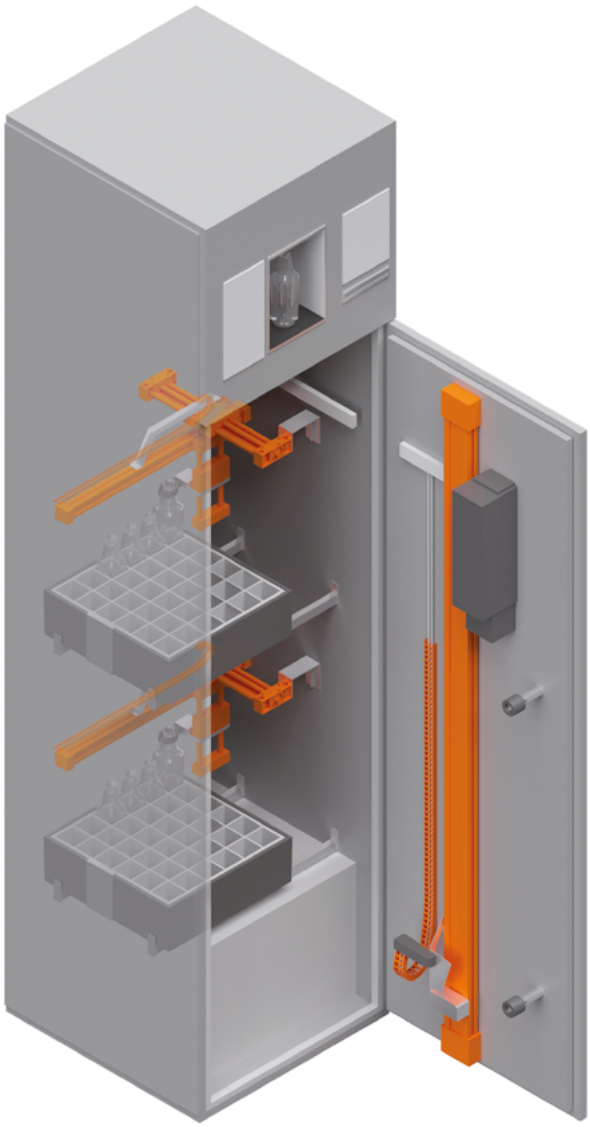


WHITE PAPER:

Linear robot systems for 24/7 maintenance-free operation

"Build or buy?": advice on vending machine design

February 2022

Introduction

Vending machines are in vogue. The manufacturer must determine how the products are stored, presented, and made available to the buyer – and how the inner workings of the movable product dispenser are designed. One option is lift systems combined with preconfigured linear robots. But there are others as well. The white paper shows what is possible and what the designer should consider during project planning to achieve an optimum vending machine for a given application.

Modern vending machines have become an indispensable part of everyday life.
Source: Adobe stock

Around three billion euros worth of beverages and snacks are sold from vending machines in Germany alone[1]. Around 600,000 vending or snack machines are installed here - 80% of them in companies and 20% in public spaces (train stations, schools, public squares, etc.)

It is an attractive market – because it is growing

Market analysis shows that this number will continue to increase, especially in public spaces. There are several indicators that this is so:

- Mobility will continue to increase.
- "Food to go" is part of everyday life.
- Acceptance of vending machines is growing.
- Cash and contactless payment of small amounts of money facilitates the transaction.

Vending machines are also already more widespread in other industrialised nations, especially Japan. Germany has one vending machine for every 130 inhabitants[1], while in Japan the figure is just under 25 - despite strong competition from "konbini" (mini supermarkets open 24/7). This is another reason to think that vending machines will continue to become more widespread in Germany.

There are other trends as well: vending machines are gaining acceptance for more and more products. Examples include cosmetics, nutritional supplements, and footwear. Vending machines are also increasingly being used for direct sales in such establishments as farm stores and for round-the-clock supply of speciality items at the point of use, right down to worm bait at fishing spots.

1) "Die Vending-Branche im Überblick", published by Bundesverband der Deutschen Vending Automatenwirtschaft e.V., 2020

Acceptance factors

Vending machines require attractive goods presentation and flawless handling of the sales process, including goods dispensing. The inner workings of the vending machines, especially the goods 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.

Four designs: flap, spiral, drum, and lift system

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 vending machines have numerous flaps, each of which opens a compartment containing a product.
- Spiral or chute machines locate goods in a 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 the product, the drum with the empty compartment rotates to the back, 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.

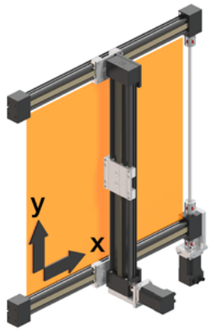
Flap, spiral, drum, and lift are the most common machine types.
Source: igus® GmbH

Advantages of lift systems

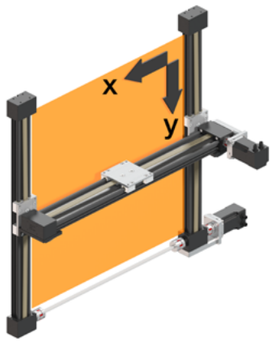
Unlike the other designs with moving components shown above, lift systems offer multiple advantages. They can convey products for sale to the output chute more gently than spiral machines can. They use space better than drum and flap vending machines do, so that they can hold more products.

Lift machines are also very flexible in terms of product size and characteristics, so they can be used almost anywhere. And the visible two-dimensional linear robot movement in front of the compartments not only ensures gentle handling, but also creates an impressive effect for the customer, who can watch product provision process up close.

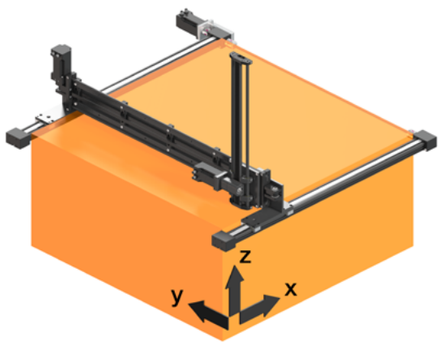
Lift machine with an igus® drylin® linear robot
Source: igus® GmbH



XY flat linear robot with a lateral linear robot orientation
Source: igus® GmbH



XY flat linear robot with a vertical linear robot orientation
Source: igus® GmbH



XYZ room linear robot
Source: igus® GmbH

Linear robot designs for lift machines

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

- In the XY flat linear robot with lateral orientation, the Y-axis moves between two horizontal X-axes and travels to the desired plane or target compartment
- For the vertically oriented XY flat linear robot, the reverse is true: The Y-axis moves between the vertical X-axes.
- XYZ room linear 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.

Drive technology requirements

Regardless of which of the three portal designs is used, what requirements must the moving components of vending machines fulfil?

- High availability: The linear robots must function reliably in 24/7 operation. Service technicians are not nearby, so they have to drive to the vending machine before repair begins. This means 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.
- Convenience: Quiet, low-vibration operation is desired.
- Broad temperature range: many vending machines provide refrigerated products, and vending machines in public areas are exposed to natural temperature fluctuations.
- Favourable cost thanks to the price-sensitive market with a short ROI.

Linear robot systems for vending machine technology

igus® offers vending machine manufacturers a range of linear robot systems that exactly meet these requirements. The flat and room linear robots have proven themselves in industrial use, where they are often subjected to much greater stresses than in vending machines. High-performance plastics with incorporated lubricant create the conditions for lubricant-free operation. It is not mandatory, but it is an advantage because it ensures that the product does not come into contact with lubricant. The axles driven by toothed belts are also characterised by smooth, quiet, low-vibration operation.

High performance and precision

XY flat linear robots:

- Load capacity of up to 80N
- Repeatability of approx. 0.3mm
- Speeds of up to 1.5m/s
- Acceleration of up to 2m/s^2

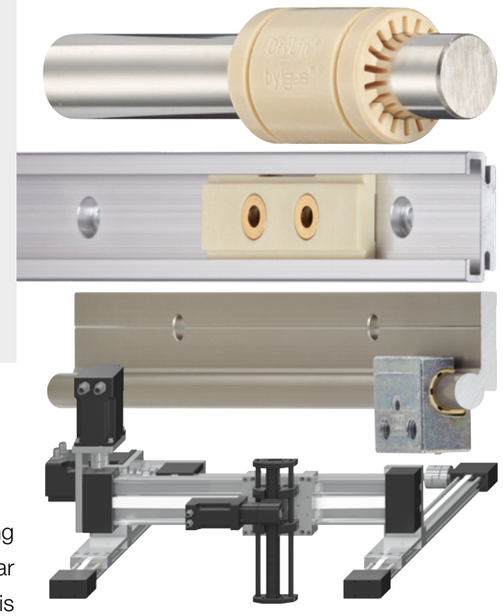
XYZ room linear robot:

- Load capacity of up to 50N
- Repeatability of approx. 0.8mm
- Speeds of up to 0.5m/s
- Acceleration of up to 2m/s^2

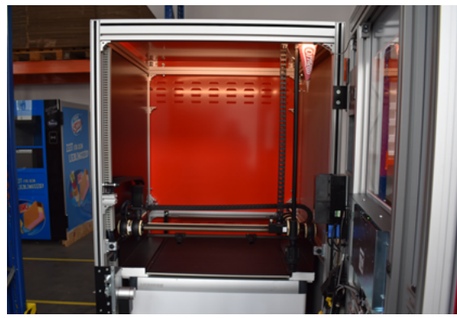
It's up to the designer

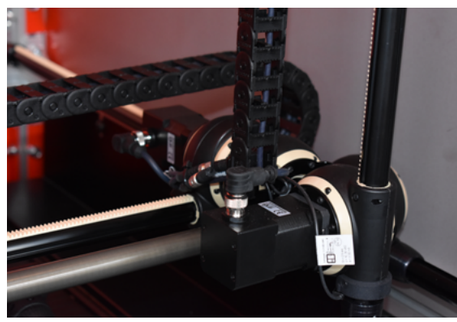
A lift system designer can use the igus® design kit without committing himself to a specific technology. This is because, in addition to the linear robot systems with toothed belt drive, igus® offers other linear axis systems that can be combined to form linear robots:

- In the drylin® linear axes with lead screw drive, linear adjustment is with 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.
- The Apiro gearbox kit enables the designer to implement Cartesian 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 with a lift system. The modular gearbox system offers limitless development options.
- Among the features of igus® linear axes with rack and pinion drive are high axis rigidity and high precision in any installation position. Rack and pinion drives also allow optimum use of installation space, so that both the vending machine manufacturer and the operator can accommodate more saleable products in the same space.

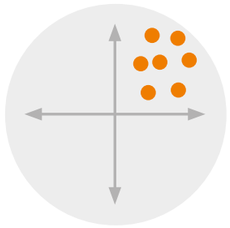


Quiet and space-saving drylin® linear systems, also with motor
Source: igus® GmbH

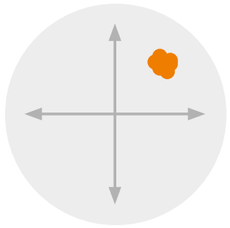




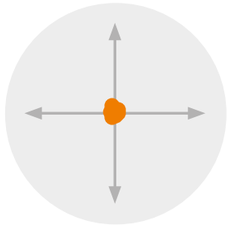
Apiro linear robot in the dispensing mechanism of an ice cream vending machine
Source: igus® GmbH



1. Low positioning accuracy; low repeatability



2. Low positioning accuracy; high repeatability



3. High positioning accuracy; high repeatability

Source: igus® GmbH

Which drive is best?

Toothed belt, lead screw, gear rack ... As with other applications, there is no one linear system that is best for automatic lifts. What is decisive is the use case and the property deemed most important in a given project.

If compactness is the key, the gear rack is probably 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 optimising repeatability

A decisive factor for flawless long-term vending machine functioning is linear robot repeatability. This accuracy depends on many factors that the designer should take into account.

Each drive and linear robot component (motor, gearbox, coupling, toothed belt, rack, etc.) can have clearance, and that can add up. The designer should use components with as little clearance as possible and keep the number of drive train or guide system components down.

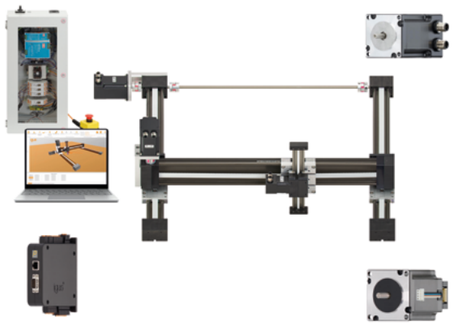
All linear elements (linear drive, guides, housing frame, etc.) can also warp, bend, or twist, impairing positioning and repeat accuracy.

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

"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.

Cooperation with igus® means that vending machine manufacturers do not necessarily have to select individual components, order them, and assemble and install them in their own production line. They can also configure a complete flat or room linear robot online. They start from a standard linear robot and make special requests to adapt it to their individual requirements.



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

Because the linear 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 linear robots.

The configuration options encompass not only the pure axes, but also all peripherals, including cables, motors, and even control systems. Here, in control technology, igus® offers its own product range that is specially adapted to the requirements of linear technology.

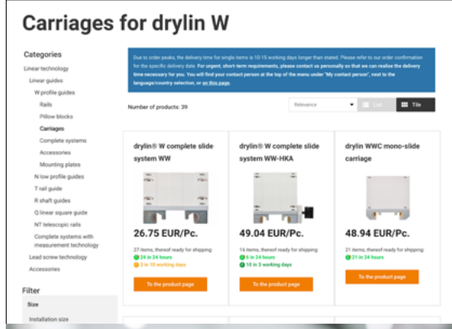
The question of core competence

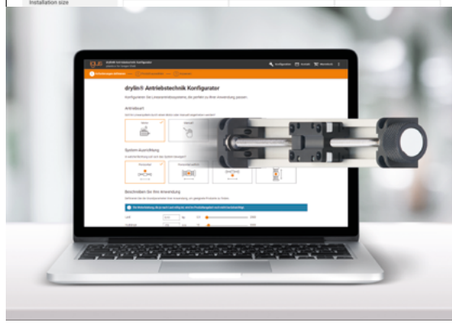
All linear robot modules are manufactured on a rack and shipped. On site, they have only to be installed and connected as a module. And if, in the end, the manufacturer decides on an in-house solution, igus® offers all components necessary for development with no minimum order quantity.

Ultimately, the vending machine manufacturer must ask himself: What is my core competence? Assembling linear systems into Cartesian robots, or designing innovative vending machines that are attractive to vending machine operators and, above all, end customers?

Don't forget peripherals!

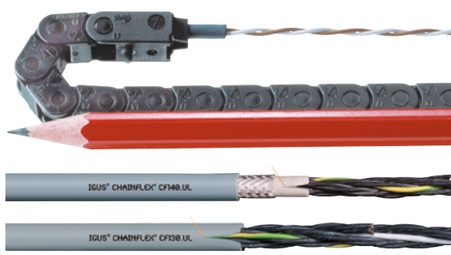
When purchasing complete modules, the vending machine manufacturer should not lose sight of individual components. After all, moving components are used not only in the a lift system's linear robot, but also in other places in the machine. Here, a design that uses the igus® building blocks is a good 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 safe side.





igus® Online store for flat and room linear robots
Source: igus® GmbH

igus® Online configurator for flat and room linear robots
Source: igus® GmbH



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

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