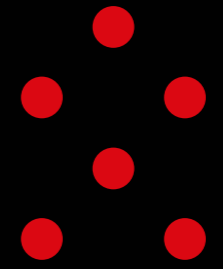


# Cube Storage Pioneers



AutoStore

# Cube Storage Pioneers

AutoStore was invented out of necessity. In the 1990's the Hatteland Group became the largest distributor of electronic components in Northern Europe. A new large warehouse was built, but shelves were filled to capacity in the first month.

Something had to be done. Instead of building another warehouse to secure business expansion, Hatteland's Technical Director Ingvar Hognaland had an epiphany: Why store things like dominos, when we could store them like a Rubik's cube?

He realized that traditional warehouses store far more air than products in the space between each shelf and above. This is wasteful and expensive in utilities and manpower. He thought of a solution to make goods come to people – instead of people running to fetch stuff on shelves.

Hognaland's desire to maximize all available space led to the fundamental design element of the AutoStore Grid. After pioneering the first AutoStore Robot for internal use, The Hatteland Group soon came to realize the products' global potential.

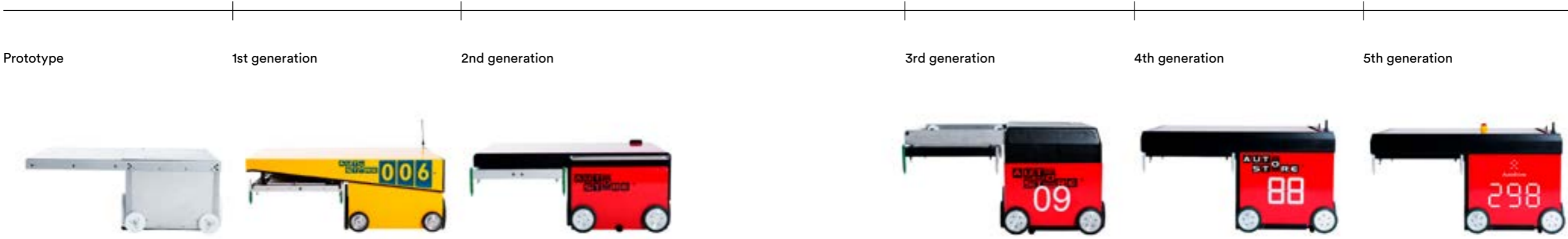
The world's first Cube Storage Automation System was born.

Since inception, Hatteland has focused on research and development of new technologies. Solutions that make daily work more accessible, more efficient and reliable. With over 20 years of experience, AutoStore has developed a solution with speed, stability, and control in mind. The pioneering spirit is an integral part of the company's DNA as its vision is to continue to invent the future of warehousing.

Now, with hundreds of systems, thousands of robots and millions of bins on all continents, AutoStore connects with businesses in a world demanding faster, tighter and no-bull material handling from the Cube Storage Pioneers.

# Timeline

1970s-1980s	1990s	2000-2005	2005-2010	2010-2015	2015-
<p>Jakob Hatteland Elektronikk AS - A distributor of electronic components and semiconductors was founded in 1971. Based in Nedre Vats, Norway.</p>	<p>AutoStore is founded. Development starts and the first prototype is built.</p> <p>The Hatteland Group expands its business area to ERP Development (RamBase), Industrial Displays (Hatteland Display), B2B eCommerce site for consumer electronics (Hattelco) and various computer services (Hatteland Supply).</p>	<p>First internal installation is put to use with the focus on development to make a commercial system.</p> <p>Component distribution business acquired by Arrow Electronics.</p>	<p>First commercial installation in 2005. Large resources used to build up the organization and to continue development</p> <p>Establishment of own production plant in Poland.</p> <p>First international installation 2009.</p> <p>Industrial Display business acquired by private equity fund Hercules in 2007.</p>	<p>Building of international and local partner network.</p> <p>AutoStore on five continents and with increasing market share every year.</p> <p>Wins innovation award at LogiMAT</p>	<p>Private equity fund EQT acquired AutoStore in 2016 with the goal of driving further international expansion and growth.</p> <p>Rapid global expansion.</p> <p>AutoStore offices in Germany, UK and USA.</p>



# The Space Makers

AutoStore is the ultimate space maker, reducing the storage footprint to a fourth to conventional storage. Elimination of traditional needs such as walkways and within height reach shelves means almost all warehouse space gets used for its purpose: warehousing.

Number-identified bins are stacked high and tight in an aluminum cubic grid system that can be formed in any shape and around obstacles to accommodate users from small and low storage points in Hong Kong, to massive Distribution Centers in the Nevada desert.

With the highest density of any goods-to-person system there are many possibilities: get four times the storage capacity out of the current building or move the DC to the city center to save shipment time and cost.

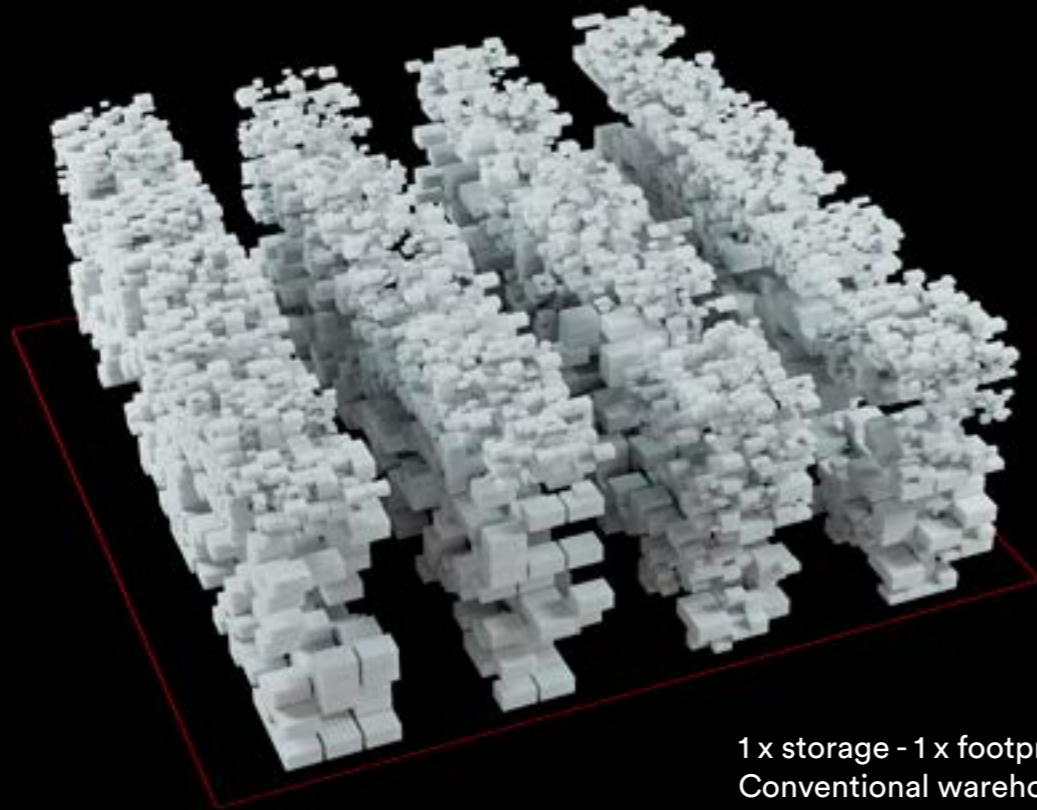
The AutoStore effects are significant and often kept as a confidential competitive edge among many of its users.

## The Bin Movers

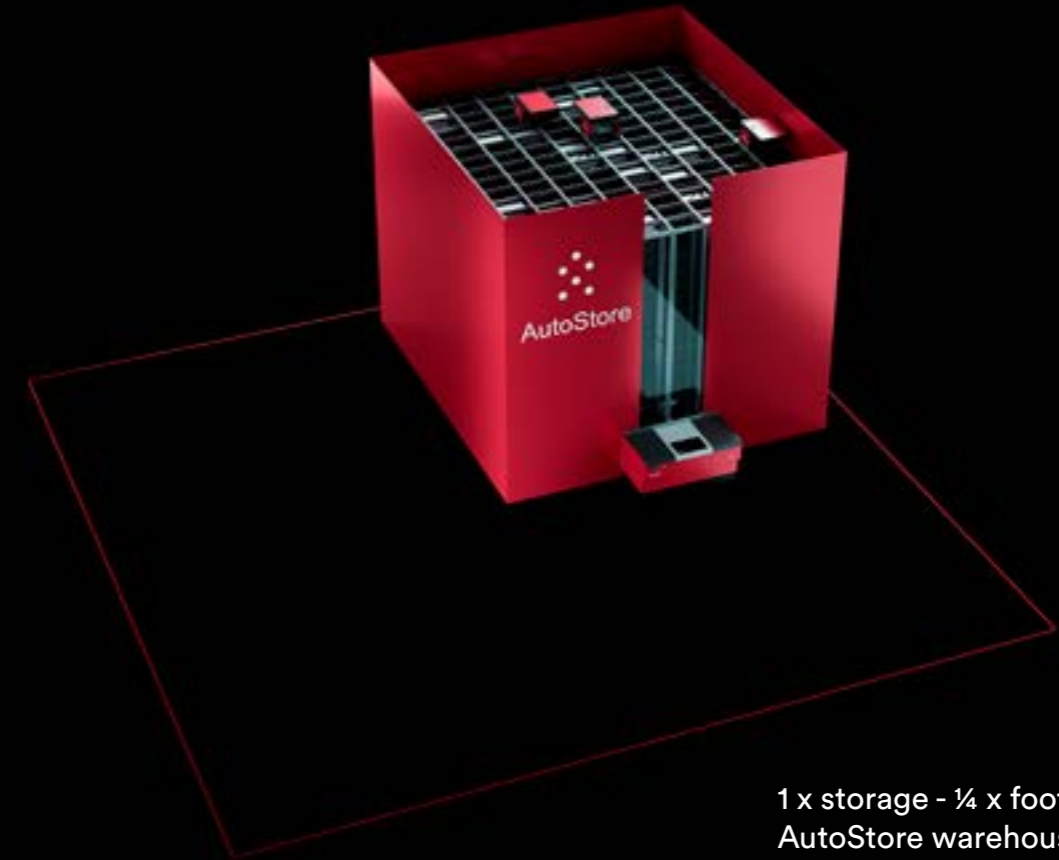
The top of the grid is reserved for high-speed robots that work all day shuffling bins and delivering orders to the workstations on the grid-edges where humans pick or replenish inventory.

AutoStore is a completely modular system, and the number of robots and workstations determine what throughput performance is possible. Its modularity is enjoyed by world's biggest eCommerce companies on black Fridays. At the same time by Swiss watch makers needing production-kits from their AutoStore every few hours.

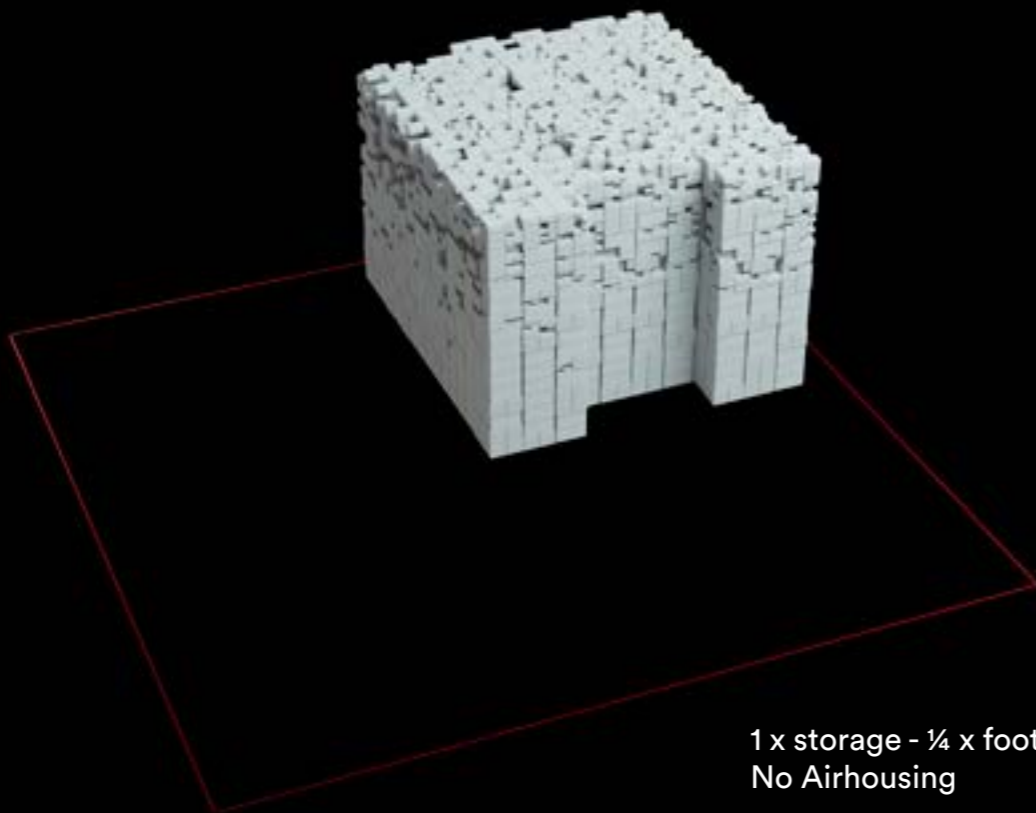
Each robot has one task: Get the bin. They work independently on the same playing field. Highly sophisticated logic and traffic algorithms make the totality of AutoStore work as a finely tuned machine.



1 x storage - 1 x footprint  
Conventional warehousing



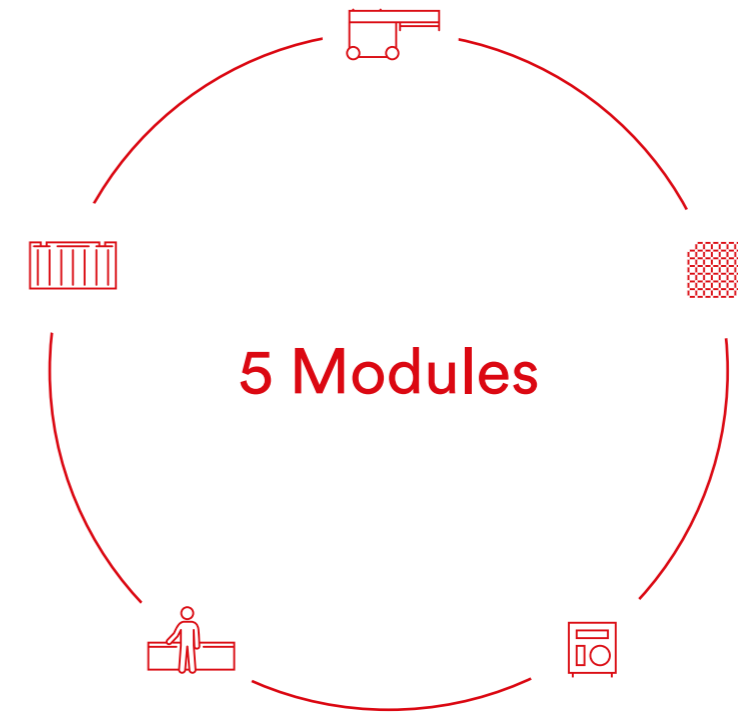
1 x storage - 1/4 x footprint  
AutoStore warehousing



1 x storage - 1/4 x footprint  
No Airhousing



4 x storage - 1 x footprint  
AutoStore warehousing



### The Five modules

AutoStore is assembled with five modules. Two moving modules: the robot and workstation. Two static modules: the grid and bin. Controller is the command center.

### Ports

AutoStore workstations are called Ports. This is where bins are presented for picking, replenishing or other inventory actions. We have a range of Ports for various functions and speeds

### Robot

Hardworking robots drive along the top of the grid and will retrieve any bin, from top to bottom, with gripper plates. All robots are wirelessly connected and will charge themselves when not in use.

### Bin

Durable, specialized and stackable bins made to hold inventory and the weight of many other bins above.

### Grid

The aluminum grid holds the bins stacked neatly while providing tracks for the robots to drive on. The modular grid can be built in any shape.

### Controller

Keeps track of everything. Always. This module is the command center, traffic control and database holder of AutoStore.

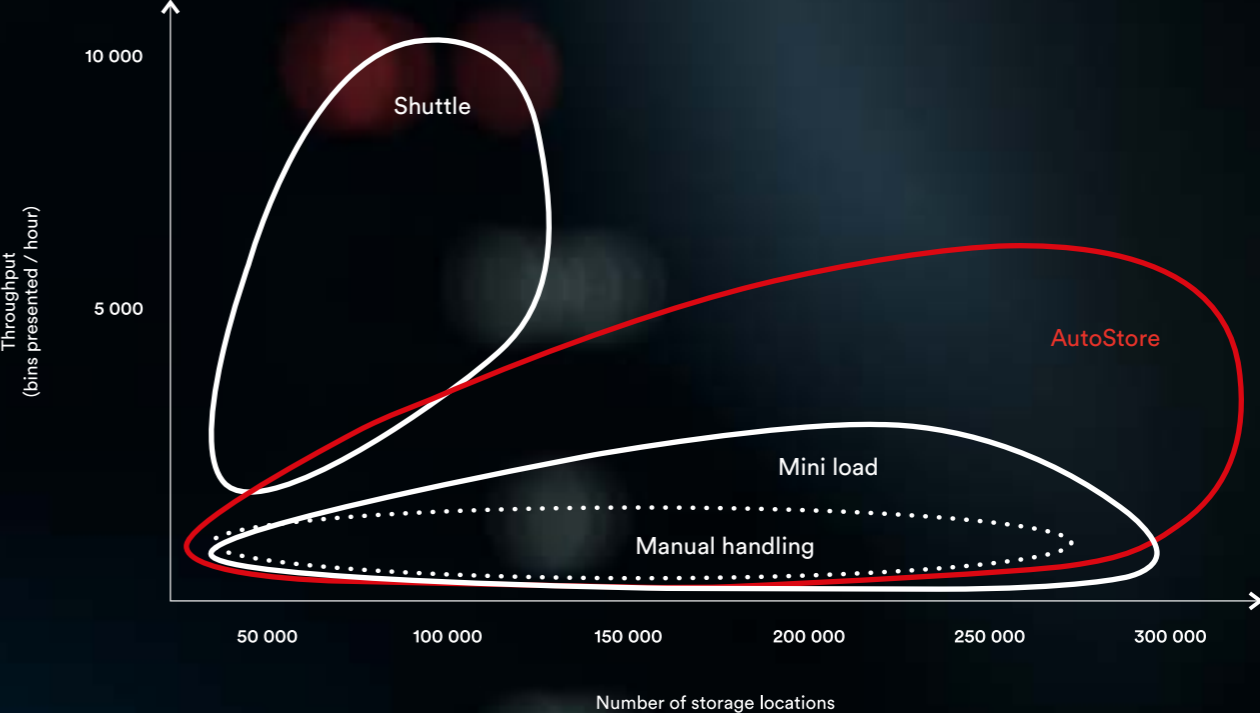


# Addressable market

AutoStore has proven to be the best solution for a wide variety of customers, industries and applications.

It not only provides the highest storage density in the market, it also achieves high throughputs.

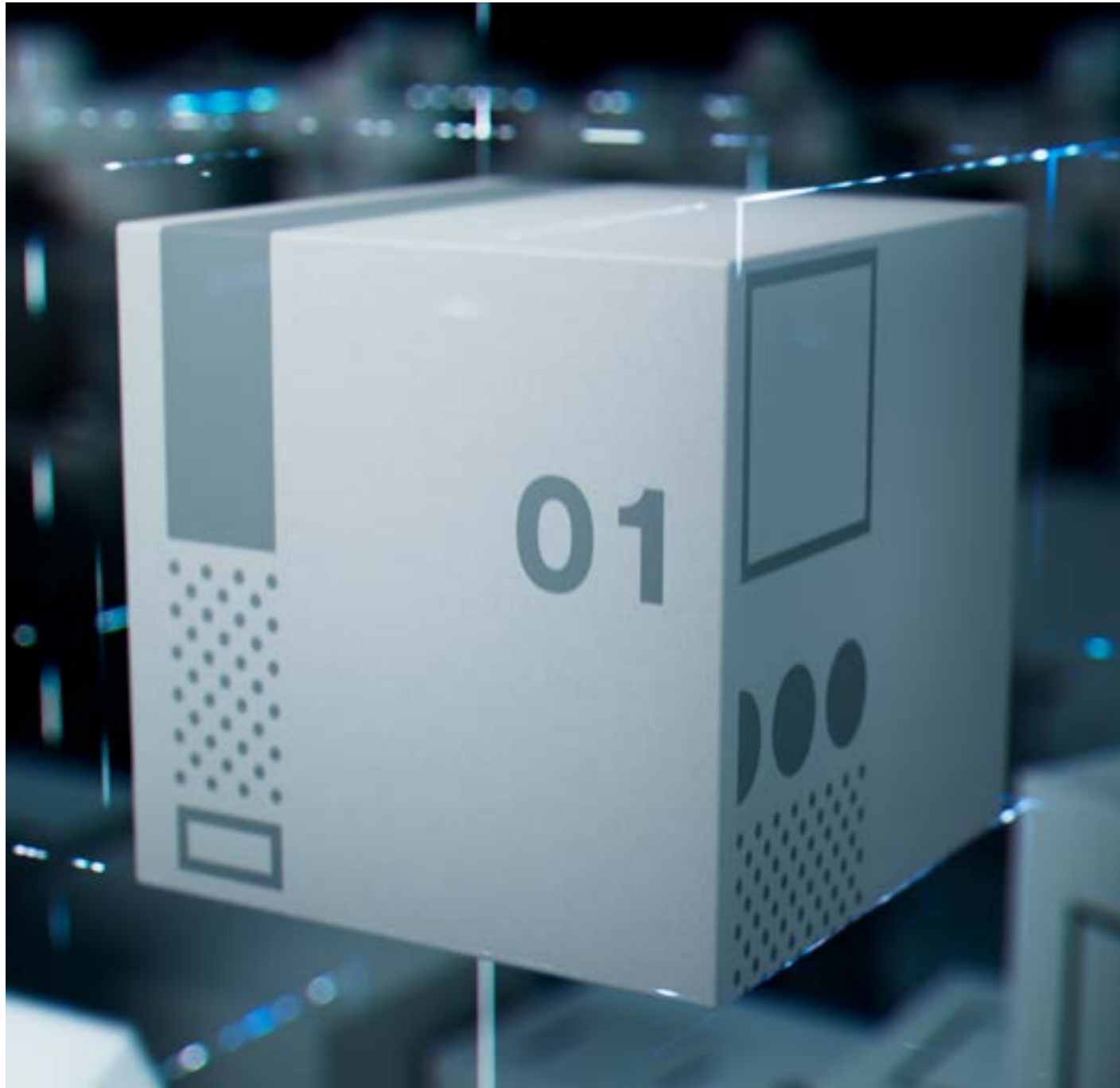
Our focus is to strengthen our position and expand the reach of today's addressable market, further developing our technology.





# System Features

## Ultra-Density



AutoStore is the very definition of space efficiency as it delivers the highest storage density of any ASRS.

With AutoStore you'll get four times the storage capacity in the same footprint as manual storage, and in many cases double the storage capacity compared to other goods-to-person systems.

With any shape possible, utilization of the building is at its peak. Several business cases show how AutoStore merges several warehouses while adding capacity.



99.6

99,6 % uptime  
worldwide average

We know the importance of writing quality code, using durable materials and challenging innovation. Reliability is one of our core values, and we see it as our top priority as an ASRS provider.

Our hundreds of systems in different segments, business climates and cultures show a combined worldwide average uptime of 99.6%. If keeping things running is an art, AutoStore is a master

A central mantra for our modular system is to have no-single-point-of-failure, so no component has the power to create catastrophe. Robots are continuously self-diagnosing and reporting back to an intelligent notification system that preventively notifies if a unit needs care.

For movement exceptions, Robots will autonomously correct itself with our XHandler program.



## Flexible & Future proof

One thing is sure: your business will change. That is why we offer the market's most flexible automated warehouse solution. Add robots while the system is operating for higher performance or expand the grid and add more bins for increased warehouse capacity.

Our grids are expandable in all directions. Some of our most successful customers are expanding for the 14th time this year.

Heavy machinery and building reconstruction is not needed for AutoStore construction. As business and demand grows, the AutoStore grid grows with them

Performance is easily predicted in our grid design and simulation tools. Any customer would know what to expect when adding new Robots, additional Grid or Ports.

Build for today - Expand tomorrow.



## Digging & Natural Slotting

The Robot lowers its gripper plate into the stack, grabs the bin with its grippers and lifts it to the grid surface. The gripper plate can be lowered all the way down to the bottom of any stack.

If the Robot needs a bin on level 9, it will dig out eight bins and place them on top of nearby stacks, using the space as a temporary placeholder. When finished, another robot cleans up and puts the bins back in the same order.

After a bin has been presented at the Ports, it will be placed back on the top of a stack of bins. If the bin is popular, it will stay on the top. If the bin is very unpopular, it will eventually be stacked over by more high-running bins and sink to the bottom.

AutoStore gets natural advantages from the Pareto principle where 20% of inventory is 80% of the turnover. A cross-section of an AutoStore system is often the perfect picture of a slotted warehouse with high-runners on top and low-runners at the bottom. But there is no need to think about slotting ever again as the system naturally adapts to any changes.

For most of our systems, the robots spend most of their efforts driving and getting bins from the top layers. As orders are prepared 30 minutes before presented at Ports, the operator would never wait or even know if a bin has been retrieved from the bottom.



## Green

Our robots use very little energy. Normal ceiling lights use a lot of power. Our robots don't need lights and will work during the night. In fact, a system with ten robots will use the same amount of energy as a vacuum cleaner.

Our Robots not only recharge themselves at the right time to avoid excessive charging, but regenerative energy functions also return power to their batteries each time they lower a bin or reduce speed.

Most buildings are made with man in mind. Many of the efforts made are power draining necessities to make it possible for human operations.

AutoStore has different needs. With more substantial utilization of building footprint; wasteful air cleaning, heating and cooling can be reduced, ceiling lights can be turned off as the robots run in the dark.



## Value adding

For a warehouse picker coming from a traditional warehouse background, working an AutoStore Port is much like trying a nail gun after working with a hammer and nails.

The grid is unreachable; its security features will decrease the loss of items. Even higher security can be added with 3rd party encryption, fingerprint scanners or similar.

With efficient procedures at the port, inventory control normally gets to over 99% as extreme precision. Data confidence comes naturally with AutoStore.





## The eCommerce booster

Global trends show urbanization and expectation of faster delivery grow in parallel. Willingness to pay shipment prices is decreasing while central property prices are increasing.

To keep up with market trends, online retailers need an ASRS that offers maximum utilization of footprint and human resources, high reliability, and accuracy in delivery.

AutoStore makes it possible to quickly install a big warehouse in a small, central location, and to build up the system phase-wise as business is growing. Implementation can be as easy as using AutoStore as a refined vending machine, or to tie in AutoStore as a part of a massive operation.

# Product features



R5

# The Robot

## A worker to rely on

Ever since the R1 was born, the iconic silhouette of the AutoStore robot appears as a moving shadow on the grid. Still iconic, but now famous and at its fifth generation with decades of upgrades; this is R5.

With a reduced number of moving parts, and with tested and trusted components the R5 is a reliable and work hungry machine that delivers all day - all night. Its sophisticated driving algorithms are played out by hassle-free and straightforward instruments making its movements elegant and refined. Complexity is understood and made smooth, tasks gets delivered wirelessly, but in small packages to avoid signal disruption. One R5 is focused on its responsibilities is without a doubt a specialist in its field. Several R5 Robots working together gives you a world-class team of warehouse workers.

- R5's running worldwide
- Minimum moving parts
- Opportunity charging
- Precision driving with Track-Sensors and recalibrating for every cell
- Balanced
- Wireless



R5

## Utterly sophisticated, brutally efficient

### One of the colony

Robots are concentrating on their own tasks while the controller directs their movements. The controller is continuously calculating the smartest way to work and will sometimes initiate teamwork where the robots dig together. A robot's task is immediately replaced by another robot if they get called to the service mezzanine.

### Nerve System

The robots are diagnosing themselves every second and will report back with even the slightest of unexpected data from its nerve system. Much like car light indicators, but with a higher degree of sophistication, you are aware of a maintenance issue and can prevent any system stoppage.

### Workhorse

R5 Robots will work 24/7 with control systems always making sure the battery is healthy. Tirelessly they have been working all over the world for over 15 years.

### Energy Efficient

Robots are continuously assigned tasks and will always get the closest task with the shortest route to save time and energy. With energy efficient motors and regenerating power; AutoStore R5 uses about 100 W - 1/10 of a toaster.

### Bowling and Champagne

The end of expansive testing periods for robot movement gets celebrated with two informal tests. One bin with a full glass of champagne and another bin with a loose bowling ball inside. The robot goes full speed, lifts, and shuffles without spilling a drop of Champagne and without releasing the bowling bin.





Weight: 148 kg (incl. batteries – without load)  
326 lbs (incl. batteries – without load)

Max load: 30 kg + ~ 5 kg bin weight  
66 lbs + ~ 11 lbs bin weight

Max speed: 3.1 m / sec = ~11 km/h  
10 ft / sec = ~ 6.8 mph

Acceleration : 0.8 m / sec<sup>2</sup>  
2.6 ft / sec<sup>2</sup>

Size: W: 700 mm / L: 963 mm / H: 545 mm  
W: 2.3 ft / L: 3.2 ft / H: 1.8 ft

Operating Temperature: 2 - 35 °C  
35 - 95 °F

Powered by Lead Acid 12V Battery  
DC Motors

# The grid

## Bin support and driving tracks.

The grid is a skeleton framework holding the system together as a cube of bins. Each cell is only centimeters apart and supports the stacked bins, but does not carry their weight. The flush connections of grid parts create easily accessible gates for the robot gripper plate to access bins from top to bottom.

Top of the grid is used as rail tracks for the robots to drive on. Tight and accurate driving demands low tolerance of building error, but with our patented and standardized grid kit, erection is done with only 15 parts and very efficient without being at the cost of precision. We can fit the AutoStore grid into buildings of any shape, all we need is a flat floor.

- Tightest storage of any ASRS system (Ultra Density)
- Aluminum grid is light, resistant
- Connected to service area - Robots drive in automatically
- Well supported - Great seismic properties
- Limited oxygen supply inside the cube

# Unsurpassed construction flexibility

## Aluminum

A light, thin, robust grid made from form pressed aluminum and CNC-machined top tracks. Aluminum metal makes way for more comfortable handling and shipment while providing solid hold integrity.

## Brownfield, Greenfield or any field

The grid has minimum impact on buildings. Construction can easily be carried out in oddly shaped rooms and around obstacles like columns or utilities. In any form possible, footprint utilization goes to a maximum.

## Expansion

AutoStore customers don't buy a system of constraints; they buy a dynamic machine that has no intention of stopping the supply chain, even when expanding. Grid expansions can be built next to an operating grid. Once the new design is fed into the controller, robots will start testing and eventually fill it up with bins. All without losing precious running time.

## Construction time

Time of completion is one of the fastest in the industry as the erection itself is repetitive and uncomplicated. Depending on size, the construction period can be expected to take from 1 to 3 months.



## More layouts with BinLift

BinLift connects grids and vertically extends the bin reach with up to 16 meters (52.5 feet) below the grid top.

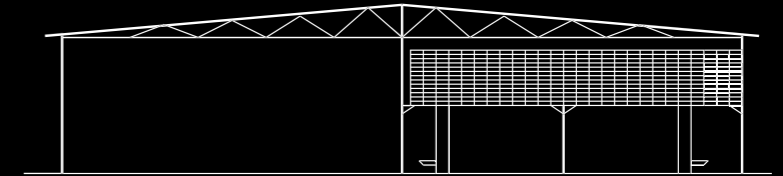
Robots place bins on a lift plate inside the grid and the bin elevates to connected infrastructure.

A flexible element to the modularity of AutoStore. Many layers of AutoStore connected (3), or full inventory access several floors below the AutoStore (2) grid is possible.

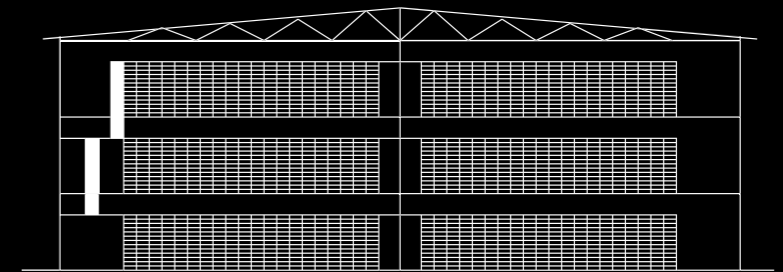
1. Surrounding columns



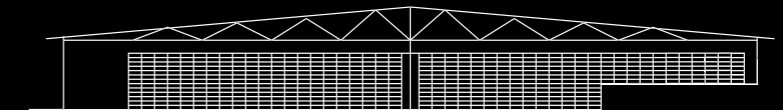
2. Mezzanine placement



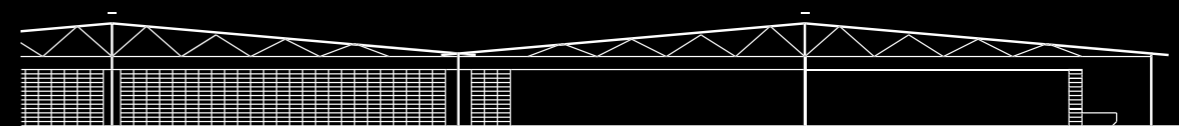
3. Several levels or floors (cake layers)



4. Different heights



5. Satellite Ports or more cubes connected





# The Bins



## Practical & Functional



16 24



5.4 m  
17.7'

Bucket, tote, container or box.  
This is the AutoStore Bin.

A robust, stackable, functional plastic form to keep inventory safe and stowed properly inside the cube. Crucially engineered and tested for function, durability and affordability.

Bins hold bicycle parts and dance costumes, the newest tablet and industrial bearings.

Several million bins are stacked in cubes in a broad range of industries.

A full AutoStore stack is  
16 bins (330mm / 13" bin)  
24 bins (220mm / 8.7" bin)  
5.4m / 17.7' tall

# Made to hold

## Partitions

With 20 divider slots, all AutoStore bins can be divided into smaller compartments adapting to the size, volume and number of different references needed. Each bin can be divided up into 32 individual cells by cardboard, plastic or steel dividers.

## Designs

With four specialized gripper holes and open corners for grip alignment, the bins are perfectly balanced to be gently and efficiently operated by AutoStore Robots and Ports - And to be stacked on top of other AutoStore bins.

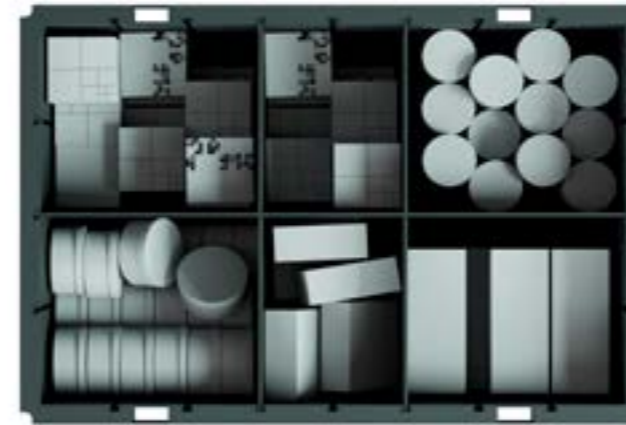
## Materials

The bins get produced in high-density polyethylene (HDPE), or polypropylene (PP-ESD) (Antistatic).

## Green life cycle

Each bin is made for extended precision and heavy load situations. They can hold the weight of a stack of full AutoStore bins. Even when the bin's lifetime is over, the 100% recyclable plastic can continue its purpose in another form.

Outer Dimensions: 649 mm x 449 mm / 2.1' x 1.5'  
Inner Dimensions: 601 mm x 401 mm / 2' x 1.3'



330 mm  
13"



220 mm  
8.7"





# The Ports

## 100% Accessibility

Bins are delivered to our workstations; the Port-family.

Our Ports are used for efficient picking and replenishment - with different movement and design features for accessibility, efficiency and cost preferences.

With all Ports there is no dedicated inventory allocation. All Ports can get 100% of the bins unless the software is configured otherwise.

We design all Ports with safety, ergonomoy and the worker in mind.

## CarouselPort

### Three armed high-speed Port

Port-time is valuable. It needs to be busy and bins must be presented at just the right time. CarouselPort is designed to operate in harmony with the robots to ensure it is always full of ready bins.

CarouselPort operates with three rotating arms, each holding one bin tray. Usually, two of the arms are positioned in back of the Port where Robots can place or retrieve two Bins simultaneously. The third arm then is in the front position where the operator can access the goods inside the Bin.

By studying the minute-to-minute work situation at our CarouselPort, we redesigned the front-end to better adapt to the human figure. A vital gap design offers better feet position together with a three-way slidable safety plate reduces fatigue and makes the work environment more ergonomically pleasant.

Max Bin throughput:  
500 bin/h Mezzanine level  
400 bin/h Floor level

Bin throughput is dependent upon system design

Min. exchange time:  
2.5 s



# ConveyorPort

## Keep it simple

The ConveyorPort uses a conveyor belt to move the Bins to the operator. While one Bin is being presented to the operator the second Bin is held in place above the Port by a Robot.

Completely removed from complexity, the ConveyorPort is a workstation in its simplest form. Bins gets dropped on a conveyor and is conveyed to a opening outside of the grid. Smart covering and sensors keeps the operation safe.

For many users, all they need is the ConveyorPort - simply a Port to access all bins inside.

Max Bin throughput:  
240 bin/h Mezzanine level  
180 bin/h Floor level

Bin throughput is dependent upon system design

Min. exchange time:  
5 s



## SwingPort Vertically Connected

SwingPort uses a rotating arm to move the Bins to the operator. While one Bin is being presented to the operator the second Bin is waiting on the opposite end of the arm.

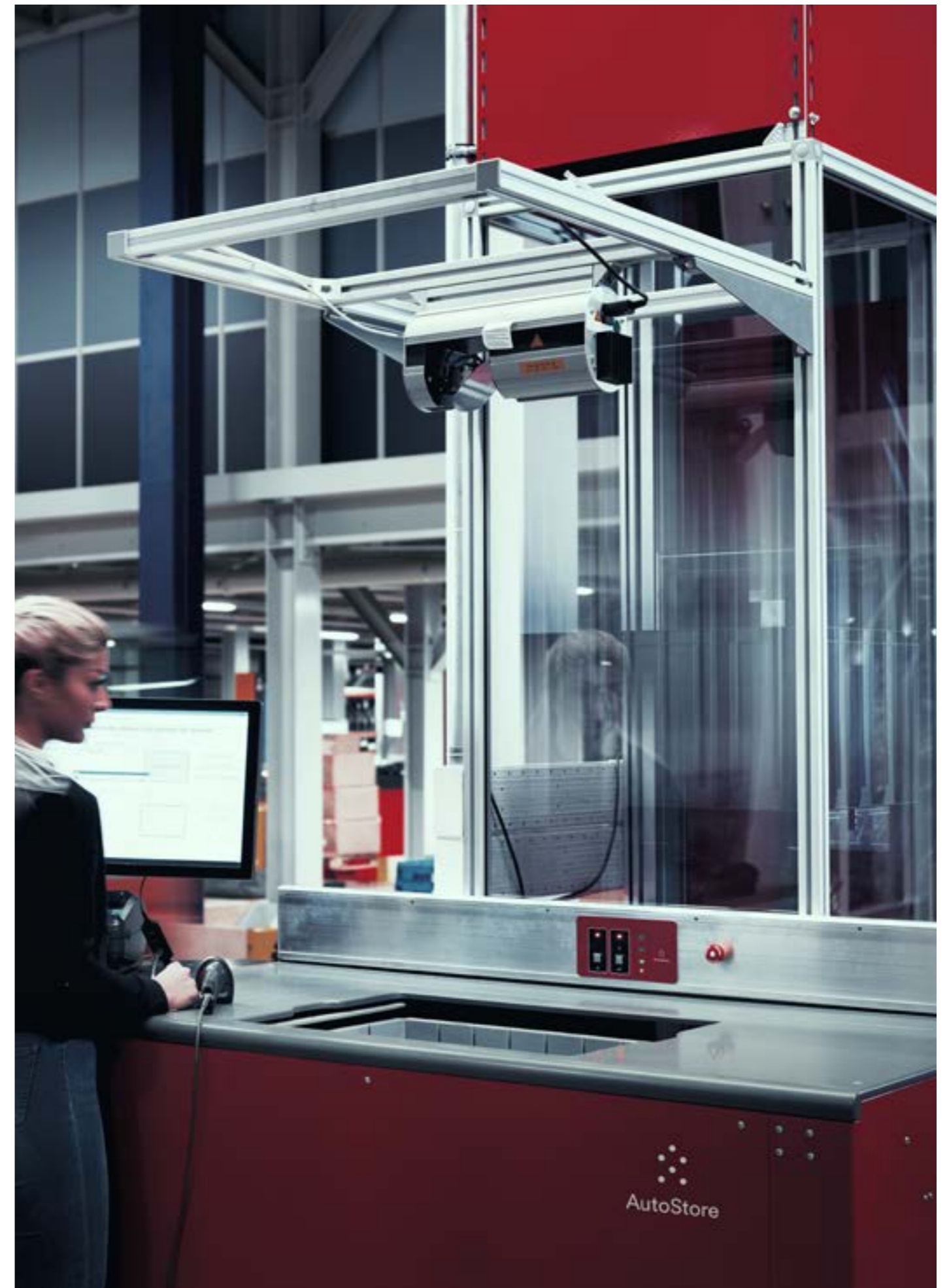
SwingPort was made to be connected to the grid as an additional offering to our workstation portfolio, but firstly to places where the robots do not reach. SwingPort will typically be linked to the BinLift and extend the bin reachability to far below the grid area.

Ergonomy and user safety have all been taken into consideration to create the ideal work environment for the user. The bin opening is shielded from the user with a hatch to provide high safety and noise reduction.

Kerrock top-plate and aluminum furniture. The SwingPort is equipped with a 50g sensitive weight.

Max Bin throughput:  
160 bin/h with 8 m BinLift & Operator handling time 15 s

Min. exchange time:  
3 s



# Controller

## The Mastermind

With over 20 years of control development, our state-of-the-art traffic system is in its own league. Not only is it fiercely sophisticated, but incredibly stable. Efficient traffic handling is our core focus, and we take great pride in always refining rules and making new, upgraded algorithms. Even though the task at hand is enormous, its elegant software infrastructure is not heavily driven.

## The Hardware:

- Industrial Rack PC - For all operations.
- ASIO - AutoStore Input and Output unit is where all safety equipment is connected.
- UPS - All AutoStore Controllers are backed-up with a 2 hour UPS for controlled shutdowns at power failures.
- ASAP - AutoStore AccessPoint is the wireless communication system between robots and controller running at 2.4 GHz.
- Standard system setup includes an extra Controller as backup.



# Smart moves

## Featured software modules

### Planner

Planner runs the overhead traffic planning and administration. It takes into consideration factors like robot positions, battery statuses, directional setup, order queues and priorities, port activity, planning of bin preparation (dig up) processes, etc. and makes the best choices to maximize the robot utilization.

It will continuously calculate the most efficient future route and action for all robots, with the goal to distribute the order list coming from WMS to the ports. Planner makes sure bins from anywhere in the grid get delivered to the ports in a steady stream. Some describe Planner algorithms as playing multiple chess boards against each other.

### Driver

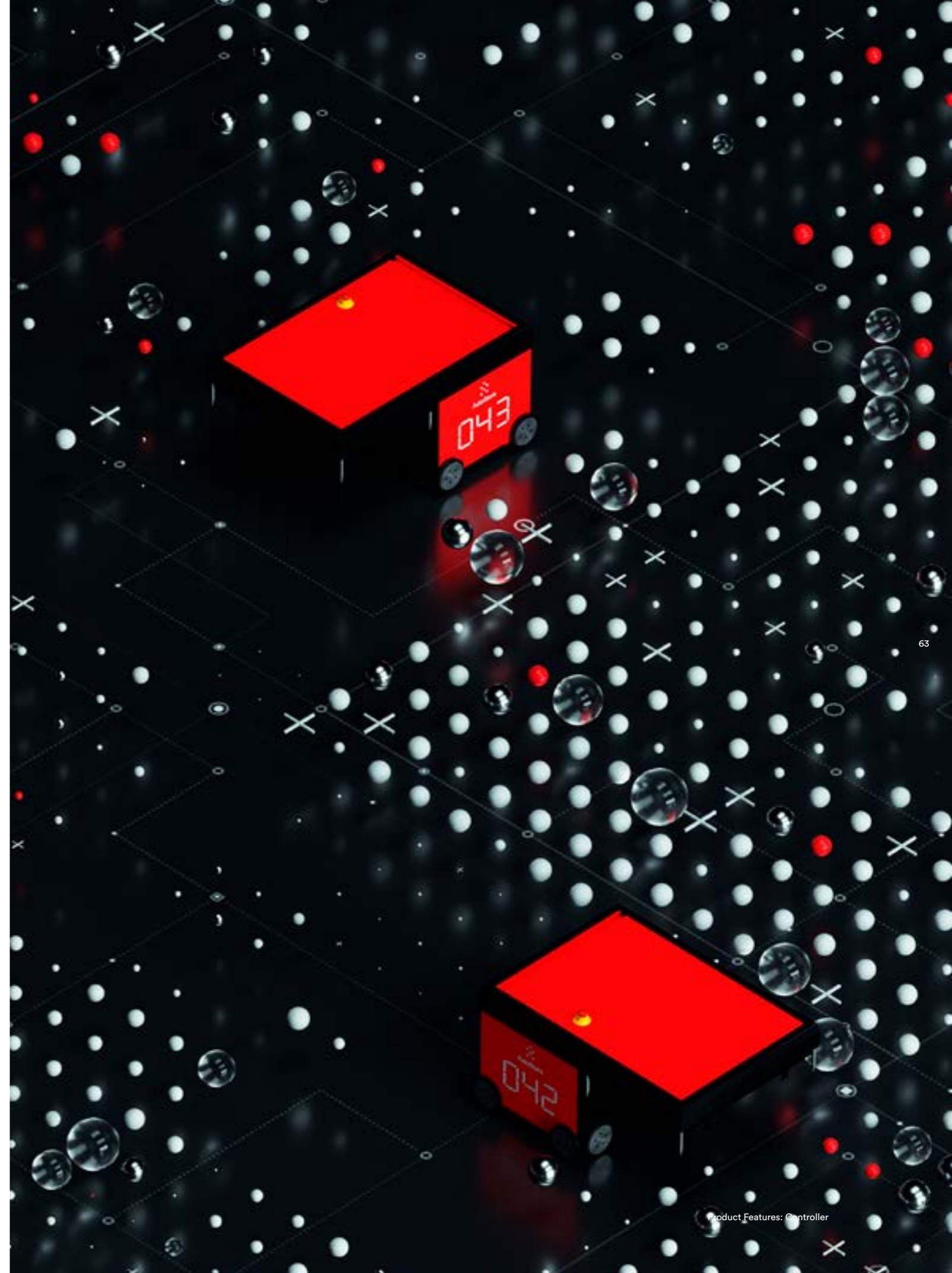
All radio communication and robot guiding go through the Driver, like a vast communication central. It is the software module that keeps all the physical parts safe, working and always backed up.

### XHandler

The AutoStore XHandler autonomously handles specific error exceptions in an AutoStore system without shutting down operations. If a robot loses its position, XHandler will block a safe area around the robot and help determine the location by identifying the nearby bin pattern. If XHandler can't determine this, another robot will make a unique bin pattern (depth of several bins). If it can't, another robot will make a unique bin pattern by removing a few bins. XHandler removed system stops to an already stable system by 80% when introduced.

### Logging

Everything that happens with an AutoStore system is logged and is traceable. The system cannot lose a bin, or its basic logic would not work. Extensive log reading and analyzing is a big part of development.







# Implementation

All AutoStore systems are part of extensive infrastructures. We have made it our mission to make system implementation safe, comfortable and hassle-free.

## Black box

AutoStore keeps perfect track of bin locations and does not operate on an inventory level. Meaning: It does not know what is inside the bins. The communication between end-user infrastructure is based on bin IDs, not on item orders.

## API

Our Application Programming Interface (API) enables the user's warehouse management system (WMS) to integrate with AutoStore.

There are two different levels of integration:

**Task Interface**  
The Task Interface operates at a picking list level and offers a higher level of abstraction than the Bin Interface.

**Bin Interface**  
The Bin Interface operates at a lower level and gives the WMS more control of the processes. It places more responsibility for grouping, preparation and optimization logic on the WMS.

## Port Interface

Port Interface API enables the integration of 3rd party Port designs. This allows bins to be taken out of the grid, such as on an external conveyor system. We recommend to keep the bin in a closed loop and avoid handling that could cause disfiguration of stacking or robot handling properties.

# The AutoStore effects



## The Spacemaker

The AutoStore system uses space to its full capacity. This is the future of warehousing. We make goods come to your employees, helping your business achieve speed and space efficiency you never thought possible.



## Simplicity

AutoStore robots operate on top of the grid. They receive their orders wirelessly from the control system, sending them to and from the ports. They pick up and deliver goods, refill empty bins and store new goods in the grid, seamlessly and efficiently tracking goods from inbound to outbound.



## Future proof your space

Designed to handle high levels of product intake, the working areas easily cope with seasonality or increases in product throughput, economically and efficiently.



## Grow while running

One of the most desired benefits with AutoStore is the possibility to expand the system - without stopping the system. Performance is increased by simply adding robots or modules, growing your inventory capacity without losing operation.



## Robots charge while working

10 robots use as much energy as one vacuum cleaner, as efficiencies and energy savings are produced with each product movement. AutoStore recharge at the right time and use regenerative energy from lowering a bin or reducing speed.



## Green usage and cost savings

AutoStore's green credentials are unmatched. Zero energy is wasted, lighting and heating requirements are drastically reduced and the lifespan of buildings can be prolonged. Reducing the cost of electricity, heating, waste and empty storage is the smart move.



## Customized for your needs

No two AutoStore installations are alike. We customize to each customer's needs, ensuring the best performance. AutoStore is a module based system and is highly configurable.



## Design & Simulation

Tried, tested and trusted. Every AutoStore system is thoroughly designed and simulated for maximum performance and capacity before installation. We work with logistics managers to design installations, simulate system performance and consider future expansions.



## Smooth system integration

We speak your language. AutoStore is currently connected to hundreds of different warehouse management systems (WMS) around the world. AutoStore connects to other WMS's via standardized API, through XML/HTTP post communication.



## Reliable space

99.6% uptime. We understand that reliability is vitally important. Every system is backed-up and equipped with UPS for controlled shutdowns should a power outage occur. AutoStore has customers across the globe, and we build to high standards from proven components.



AutoStore is distributed, designed, installed and serviced by a network of qualified partners. Find your local partner, case studies, videos and more information on:

**autostoresystem.com**

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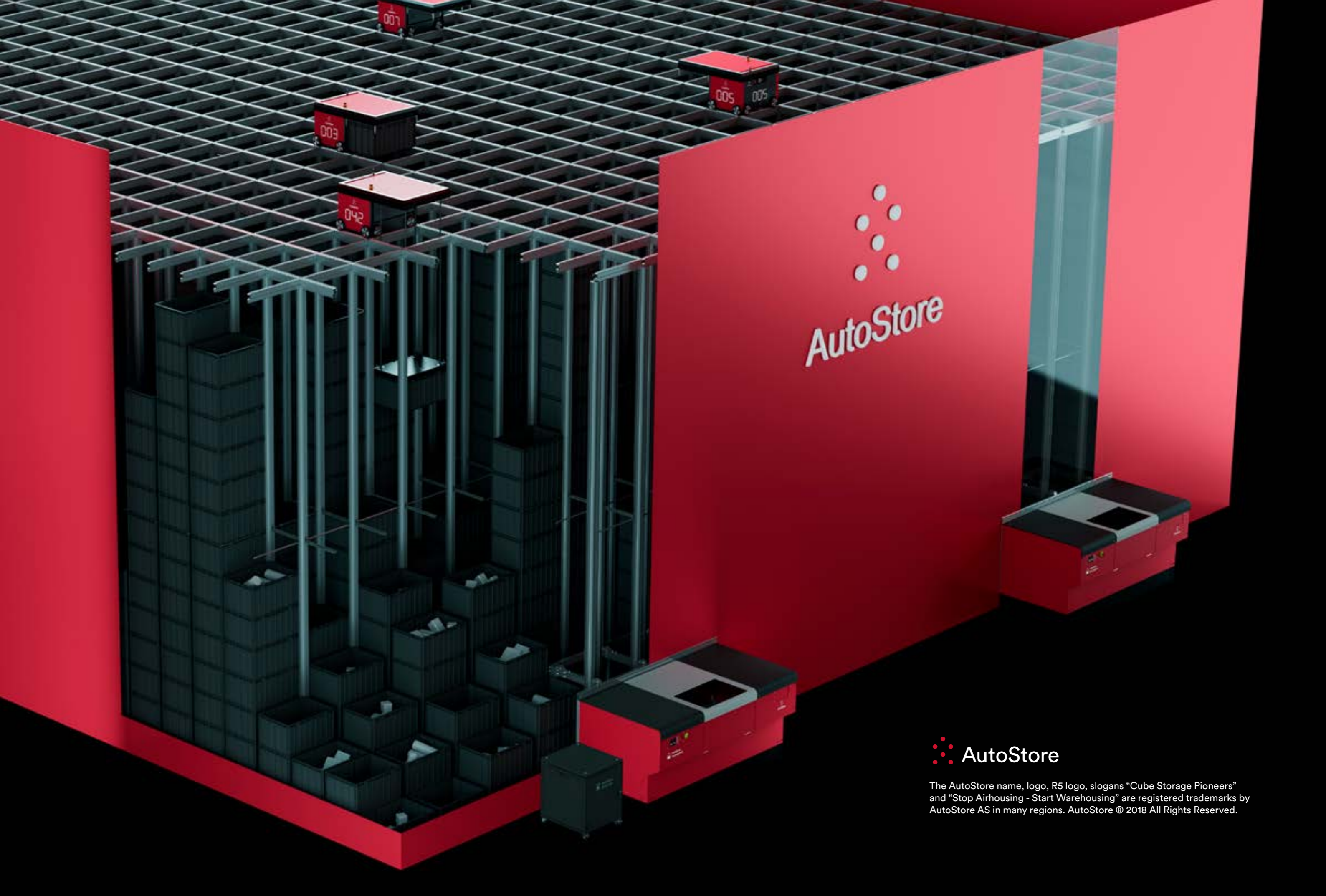
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Illustrations:  
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Photography:  
Fredrik Ringe  
Marc Gysin



  
AutoStore

 AutoStore

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## AutoStore

Automatic Storage and Retrieval System (ASRS) with a unique Goods-to-Person solution in the Cube Storage Automation category.

AutoStore was founded by technology company Hatteland Group in the 1990s. Since its first commercial delivery in 2005, the company's system has been installed for hundreds of users in 25 countries across five continents. AutoStore is headquartered in Nedre Vats, Norway, with production in Poland, regional offices in Germany, UK and USA.

[autostoresystem.com](http://autostoresystem.com)