PBC Linear

How to Design a Kiosk for Unattended Retail

An Overview of Cartesian Robot Delivery Systems

Introduction

The fast growing acceptance of kiosks and unattended retail purchases has presented new challenges for the design and engineering team tasked with creating a customer friendly experience. In the United States, DVD rentals via kiosk were estimated at over $2 billion in 2010. In the country of Japan, there are over 5.2 million unattended retail machines. That is 1 for every 24 people. In 2009, it is estimated that the Japanese spent over $62 billion in these types of machines. And there are no signs of the global trend toward self-service retail slowing down. Consumer markets are expanding their usage beyond movies and snack foods, into pharmaceuticals, high tech electronics, games, cosmetics, and more. Additionally, manufacturing companies are also embracing the technology as a way to control inventory and have readily available parts or tooling for assembly lines.

For the designer, engineer, and builder of these kiosk and handling systems, a large amount of focus and energy must be put into the front end interface. Here a user will first be met by digital signage, touch screens, and software interfaces. There are many resources available

on the technologies driving the front end design, such as graphics, GUI development, payment methods, security, and RFID identification.

However, an unseen yet integral part of the positive customer experience takes place inside the framework of the machine. That is where the product to be delivered is picked from its location, transferred from inside the machine, to ultimately be placed in the hands of the customer. If there is an unforeseen problem, the entire customer experience will end badly. Remember the feeling you had when the candy bar you paid for became stuck, barely out of reach on the other side of the glass. That type of frustration by the user will lead to a downturn in repeat sales, and a poor reputation for the vendor and the machine designer / builder.

How can a design team ensure the best in customer satisfaction when delivering the product in an unattended retail situation? In this white paper, we will look at key items that will help a project and design team when selecting the partner and components for your product delivery system.

How can a design team ensure the best in customer satisfaction when delivering the product in an unattended retail situation?

First Things First… Know the Parameters

It is always a best practice to gather as much information as possible about a potential application or design at the very beginning. That sounds like a basic statement of something that should go without saying. However, many design teams have found that they were in trouble part way through a project, or even after product was delivered, because not all of the parameters were known up front. Below is a list of the major items that should be known going into a design project. It is not an all-inclusive list and should be adapted to the needs of your organization or project.

Kiosk / Unattended Retail Application Parameters

Corporate Parameters

- Understand goals of entire management team
- Profitability goals
- Brand image and aesthetics maintained
- User privacy protected
- Product and data security

Commercial Parameters

- What is the project budget?
- What is the target price per machine?
- Traffic patterns at machine location
- Estimate daily / monthly / yearly usage
- Project due dates / timelines

Presentation Parameters

- Graphics / logos / etc.
- Touch screen / keypad
- User interface for software
- Swipe or scan for transactions

Environmental Parameters

- Indoor / Outdoor extremes
- Direct sunlight or covered
- Heat dissipation of internal components
- Moisture / Humidity

Engineering Parameters

- Product to be delivered / size / shape / weight / packaging
- Size of enclosure / inventory capacity
- Product selection and delivery system
- Selection of mechanical and drive components - repeatability, accuracy, load and moment capacity, installation and alignment
- Estimated electrical requirements
- Accessibility for inventory / maintenance
- Life expectancy requirements of machine and individual components*

**NOTE: Often the limiting factor for life is the cable management system*

Other Parameters

- Effects from shipment of machine
- Prototype and pilot tests
- Internal assembly or contract builder
- American Disabilities Act (ADA) or other requirements
- Offsite troubleshooting/diagnostics
- Connectivity for inventory control

The remainder of this white paper will be dedicated to engineering parameters as applied to the mechanical delivery system and linear motion components.

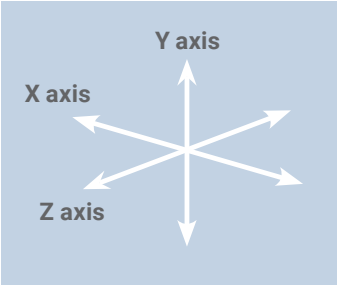
3 Basic Types of Mechanical Retrieval and Delivery Systems

Once the type of product, weight, travel life expectancy, and other factors surrounding the choice of mechanics are known, there are three basic configurations of mechanical delivery systems utilized in automated retail applications from which to choose. Each has distinct advantages based on certain parameters in the design such as those mentioned above, the structure the mechanics are to be housed in, environmental conditions, and more.

1. **Carousel Type** – product is inventoried on racks that are oriented on a circular, rotating table. The vertical or "Y" axis moves components that pick the item and deliver it to the customer. Normally the vertical axis is driven along a single rail or guide fixed to the base or one side of the enclosure.
2. **"H" Type** – product is inventoried on shelves or racks in the enclosure. The vertical or "Y" axis guide rails support and provide movement for a single horizontal axis rail that moves back-and-forth along the "X" axis. Supported on the "X" axis are the slide components that provide the in-and-out movement for the "Z" axis and support the picking mechanism. The vertical rails can be mounted to one side or in the middle of the enclosure enabling product to be inventoried and picked from both sides of the assembly.
3. **"I" Type** – the horizontal "X" axis is guided by two rails that support a single vertical "Y" axis rail. This "Y" axis rail supports the slide components that provide the in-and-out "Z" axis movement for retrieving and delivering the end product to the user.

Comparison of Mechanical Retrieval and Delivery Systems

Type of System	Carousel	"H" Type	"I" Type
General Characteristics	Compact to medium range storage	Tall, vertical storage systems	Long, horizontal storage systems
Typical Size Range	3'-4' square area	3'-4' wide x 8'-10' high	3'-100' long x 4'-10' high
Typical Load Range	Ounces to 5 lbs.	Ounces to 15 lbs.	Ounces to 15 lbs.
Typical Usage	Consistent size packaging (DVD, pill bottles, etc.)	Most often used in average size systems	Larger inventories (media retrieval, etc.)
Advantages	- Easy access to inventory - Less moving parts	- Often used as part of enclosure structural framework - Can maximize inventory space inside the kiosk shell	- Guide rails can be connected to reach extremely long lengths



▲Carousel Type

▲"H" Type

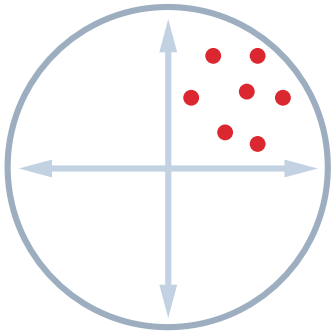
▲"I" Type

Key Design Consideration for Kiosk Delivery Systems

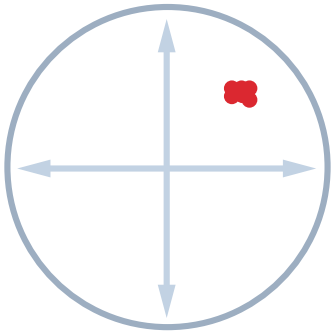
Many terms for "precision" are used and can cause confusion in the design process. A clear understanding of "accuracy" vs. "repeatability" is important to ensure the final system delivers the product to the correct place each and every time.

Accuracy is the difference between the position desired and the actual position attained. *In other words, how close to the bull's-eye did you get?*

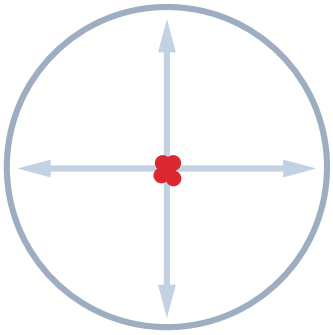
Repeatability is the range of actual positions attained when repetitively asked to return to a specific position. *In other words, how close to the bull's-eye did you get with each previous throw?*



I. Low Accuracy
II. Low Repeatability



I. Low Accuracy
II. High Repeatability

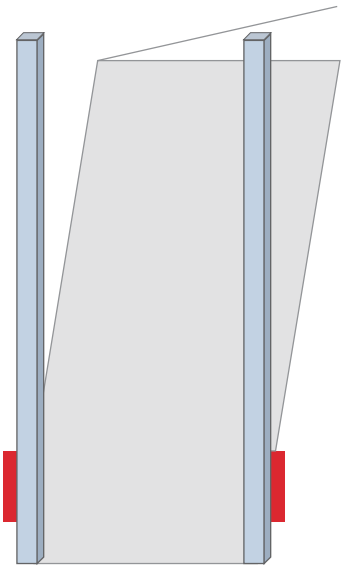


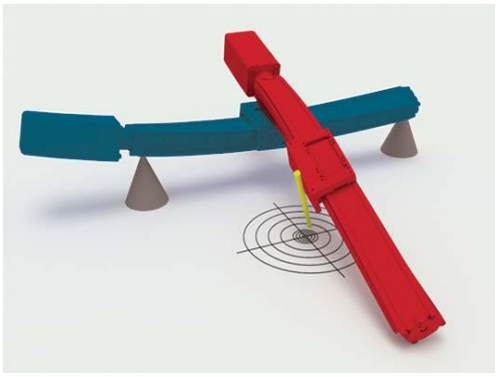
I. High Accuracy
II. High Repeatability

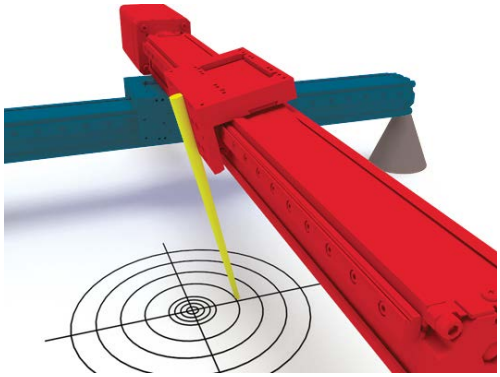
Factors Contributing to "Accuracy" and "Repeatability"

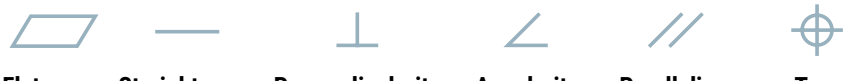
There are many areas of a design that can contribute to the final location gained by the delivery system and whether or not that location can be consistently repeated. Here are some of the factors to take into consideration during the design and analysis of a new machine.

- Backlash within mechanical drive components:
  - Gearbox
  - Coupling
  - Belt
  - Pulleys
  - Drive screw and nut
  - Motor
  - Rack and pinion
  - Etc.
- Bending, deflection, or twisting of rails or actuators
- Tilt or twist of carriage
- Bend and twist in the framework of the enclosure
- Inadequate fasteners / tightening specs allowing movement
- Misalignment or lack of parallelism during the installation process
- Tolerance stack-up
- Manufacturability not considered during the initial design engineering phase







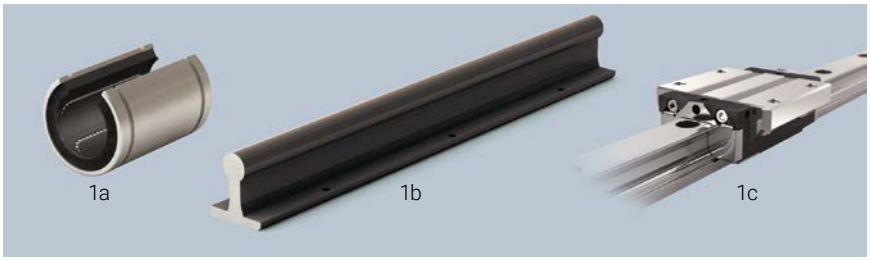


Flatness | **Straightness (of an axis)** | **Perpendicularity** | **Angularity** | **Parallelism** | **True Position**

Comparison of Linear Motion Component Technologies

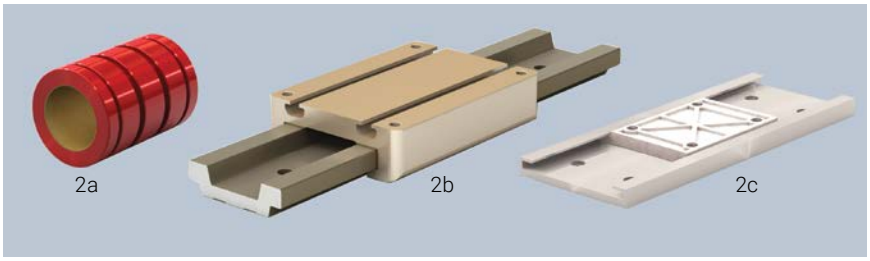
Once a basic mechanical configuration is selected and the factors involved with locating the product are understood, choosing the correct linear bearing and drive system is critical in order to reach the life cycle target, and to meet the accuracy and repeatability required. The tribological characteristics of various bearing systems will come into play with this decision.

Linear Bearing Technologies Typically Considered:



◀ Fig 1 Linear Ball Bearing and Shafting or Re-circulating Ball Bearing Profile Rail

1a. Linear Ball Bearing
1b. Support Rail Assembly
1c. Profile Rail



◀ Fig 2 Linear Plain Bearing and Shafting, or Integrated Linear Slide

2a. Simplicity Plain Linear Bearing
2b. Low Profile Uni-Guide
2c. Low Profile Mini-Rail

◀ Fig 3 Cam Roller Linear Guide Rail

3a. Commercial Rail
3b. Low Profile Redi-Rail
3c. Redi-Rail Metric

Each of these linear motion solutions offers advantages to various areas of the kiosk and unattended retail design. But which one is best suited for each of the three basic configurations typically used for the mechanical retrieval and delivery systems? And which one is best suited for each axis within the system? Where one technology may perform well and is suited to the Z-axis of the "Carousel" style system, it may fail when utilized on the extended length X-axis of an "I" configured machine.

The following will show some of the typical PBC Linear product solutions used in the X, Y, and Z axis of each configuration.

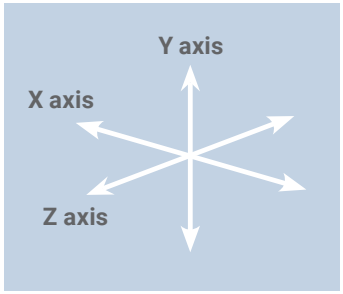
4. Integral-V Carriage and Rail

Tribological Comparison of Linear Motion Components in Kiosk Systems

Each axis should be considered individually when examining the design parameters.

The X-Axis chart below applies to:

- "I" format - two horizontal rails for the "X" axis.
- "H" format - single horizontal rail for the "X" axis.



▲"I" Format Gantry

▲"H" Format

Legend	
●	Meets requirements
●	Key Advantage
●	Requires accessory
●	Key Drawback / Application Concern

X AXIS		Alternatives					
		Cam Roller				Plain	Ball
Parameter	Application Notes	Redi-Rail 3c	Low Profile Redi-Rail 3b	IVT 4	Commercial Rail 3a	Low Profile Uniguide 2b	Profile Rail 1c
Load		●	●	●	●	●	●
Moment Load		●	●	●	●	●[1]	●
Repeatability		●	●	●	●[2]	●	●
Cost	Qty - 2 long rails	●	●	●	●	●	●[3]
Installation / Alignment		●	●	●	●	●[4]	●
Structural	Suitable with partial support; rail can be a structural component	●	●	●	●	●	●[5]
Maintainability	Corrosion, Lubrication	●	●	●	●	●	●
Misc						2:1 caution	

[1]Plain bearing—must NOT exceed the 2:1 ratio of moment arm length to bearing length or spacing.

[2]Bent sheet metal rail. Not as precise a product as others—possible roller to rail clearance allowing backlash.

[3]Profile rail is more expensive than the other options and with two parallel rails supporting each other, less expensive alternatives can almost always be chosen.

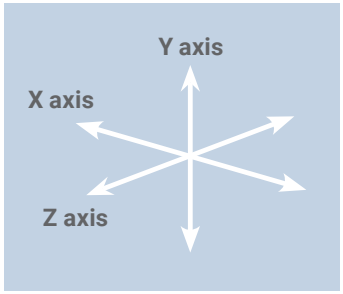
[4]Plain bearings in the carriages require the two rails to be parallel to prevent binding. Alignment is more critical than the options using rollers.

[5]Profile rail not designed for use when unsupported; either end supports only, or cantilevered.

Each axis should be considered individually when examining the design parameters.

The Y-Axis chart below applies to:

- "I" format - the single vertical "Y" axis.
- "H" format - two vertical rails for the "Y" axis



▲"I" Format Gantry

▲"H" Format

Legend	
●	Meets requirements
●	Key Advantage
●	Requires accessory
●	Key Drawback / Application Concern

Y AXIS		Alternatives					
		Cam Roller				Plain	Ball
Parameter	Application Notes	Redi-Rail 3c	Low Profile Redi-Rail 3b	IVT 4	Commercial Rail 3a	Low Profile Uniguide 2b	Profile Rail 1c
Load	Y Axis Load carried by the belt	●	●	●	●	●	●
Moment Load	E.g. 10lb at 7" (70 in-lbs.)	●[1]	●	●	●[1]	●[2]	●
Repeatability		●	●	●	●[3]	●	●
Cost		●	●	●	●	●	●[4]
Installation / Alignment		●	●	●	●[3]	●	●
Structural	Suitable with partial support; rail can be a structural component	●	●	●	●[3]	●	●[5]
Maintainability	Corrosion, Lubrication	●	●	●	●	●	●
Misc						2:1 caution	

[1]Single rail axis and carriage rollers are inline. Other products with wider roller stances have better moment capacity and rigidity.

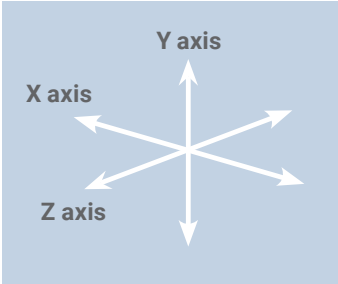
[2]Plain bearing—must NOT exceed the 2:1 ratio of moment arm length to bearing length or spacing.

[3]Bent sheet metal rail. Not as precise a product as others—possible roller to rail clearance allowing backlash, especially when a single rail is used as an axis without a second parallel rail.

[4]Profile rail is more expensive than the other options.

[5]Profile rail not designed for use when unsupported; either end supports only, or cantilevered.

The chart below applies to the "Z" axis of an "I" format, "H" format gantry, or carousel gantry. This is the axis that actuates the "picker" or end effector that handles the product.



▲ "I" Format Gantry

▲ "H" Format Gantry

▲ Carousel

Legend	
●	Meets requirements
●	Key Advantage
●	Requires accessory
●	Key Drawback / Application Concern

Z AXIS		Alternatives					
		Cam Roller				Plain	Ball
Parameter	Application Notes	Redi-Rail 3c	Low Profile Redi-Rail 3b	IVT 4	Commercial Rail 3a	Low Profile Uniguide 2b	Profile Rail 1c
Load		●	●	●	●	●	●
Moment Load	E.g. 10lb at 7" (70 in-lbs.)	●[1]	●	●	●[1]	●[2]	●
Repeatability		●	●	●	●[3]	●	●
Cost		●	●	●	●	●	●[4]
Installation / Alignment		●	●	●[5]	●[3]	●	●
Structural	Suitable with partial support; rail can be a structural component	●	●	●	●[3]	●	●[6]
Maintainability	Corrosion, Lubrication	●	●	●	●	●	●
Misc				Height limitations	Requires 2 parallel rails	2:1 caution	

[1]Single rail axis and carriage rollers are inline. Other products with wider roller stances have better moment capacity and rigidity.

[2]Plain bearing—must NOT exceed the 2:1 ratio of moment arm length to bearing length or spacing.

[3]Bent sheet metal rail. Not as precise a product as others—possible roller to rail clearance allowing backlash, especially when a single rail is used as an axis without a second parallel rail.

[4]Profile rail is more expensive than the other options.

[5]IVT products have greater minimum height requirements than some other products.

[6]Profile rail not designed for use when unsupported; either end supports only, or cantilevered.

Conclusion

Consistent positive customer experience in an unattended retail situation depends on an understanding of the design parameters and precise engineering at the beginning stages. By providing a combination of knowledge and experience with proven linear motion technologies, and technical skills in kiosk design, a long-lasting robust system can be achieved.

PBC Linear supports the kiosk and unattended retail machine designer with both mechanical knowledge and industry leading linear motion products.

- Domain Expertise
  - Multiple format experience (Carousel, "H", and "I" formats)
  - Knowledge of design parameters specific to kiosk development
- Range of Solution
  - Components–plain bearing, cam roller, linear actuators, etc.
  - Complete custom system solutions
- Engineering Collaboration
  - Component selection beyond linear guides, including motors, gearbox, cable management, sensors, etc.
  - System life, MTBF (Mean Time Between Failure), and functional testing
  - Advanced technical analysis, including FEA for stress, deflection, and vibration modes as well as DFA (Design for Assembly) analysis.
- Manufacturing Agility
  - Machine and assembly capabilities to meet demand

Further Information

For questions, contact a PBC Linear Application Engineer to discuss your application. You can contact an engineer directly by calling 1.800.962.8979 (from within the USA) or +1.815.389.5600 (from outside the USA). If you prefer, e-mail an engineer at: appeng@pbclinear.com

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