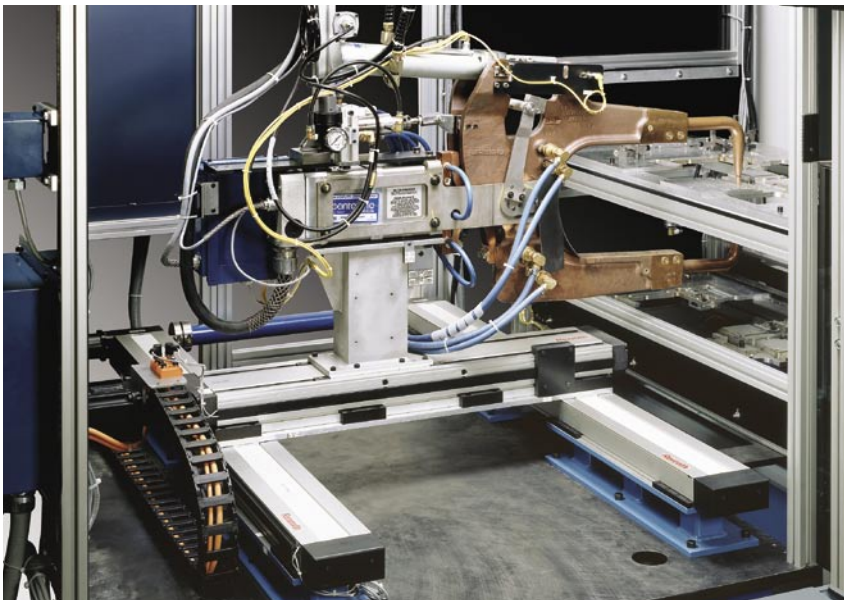
Drive & Control profile

Total Cost of Ownership and Linear Motion



A well-implemented multi-axis manufacturing system, such as this circuit breaker welding system, cuts production time, increases throughput, and improves quality and profits.

How to avoid paying 50% more than you planned.

You may not realize it, but many of the products you buy actually cost a lot more than the initial price you paid for them. For example, let's say you paid $25,000 for your vehicle. How far do you drive and how many gallons of gasoline do you use each week? How much does gasoline cost in your area? How often do you change the oil, rotate the tires, or have other maintenance work done? Over a 5-year period, these expenses, all a necessary part of operating your vehicle, can easily add up to $12,000—or approximately 50 percent of the price of the vehicle.

Add to that the time you spent picking out the vehicle—conducting online searches, reading auto reviews, and visiting dealerships or individual sellers. All of these things—both pre- and post-purchase activities—contribute to the cost of owning the vehicle. Similar logic applies in the

TCO Considerations:

- Plan well: size and select the appropriate linear module(s) for your system
- Use web-based sizing tools to drastically reduce engineering time
- Consider pre-assembled linear modules for easy installation and quick start-up
- Reduce maintenance with full-contact seals to preserve lubrication
- Save time and money by choosing a system with interchangeable components. Parts of the system can be repaired or upgraded rather than replacing the whole machine.

Pitfalls in Linear Motion System Implementation:

- A poorly implemented system costs hours of re-work, re-design and unexpected maintenance
- A system built too large for the application it serves consumes money and space
- A system not robust enough to handle the application results in poor performance and lost revenue from missed market-launch opportunities

purchase of capital equipment: It's easy to add unexpected costs to the ownership experience, both before and after the purchase, if you look only at the initial purchase price. The "cheap" solution in the short term may end up costing you more in the long run. In this article, we'll explore how total cost of ownership (TCO) applies to linear motion systems.

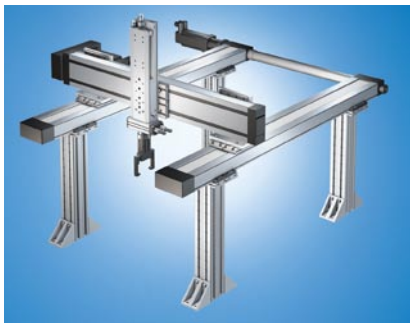
Linear motion systems, also referred to as linear modules or electromechanical actuators, typically combine a linear *drive* mechanism, such as a precision ball screw or toothed belt, with a linear *guide* system — often a Ball Rail or Cam Roller guide assembly — inside a housing to create a single linear axis. Many sizes and styles are available, which makes it easy to combine them into custom multi-axis robotic systems for a wide range of applications. Extremely small systems can be combined to create a 3-axis dispensing system for laboratory automation, for example, or very large systems may be used to build a handling system for heavy automotive components. For a more integrated system, motors, drive amplifiers and controllers are required, and to simplify specification and ordering, some linear motion companies have begun offering complete, pre-configured Cartesian motion systems. Medical manufacturing and packaging companies often choose these pre-configured, pre-assembled systems to eliminate the time and hassle of mounting and aligning multiple axes, selecting the proper motor and

Linear motion systems combine a linear drive mechanism with a linear guide system inside a housing to create a single linear axis. Rexroth Compact Modules shown here use a precision ball screw with ball rail linear guides.

drive combination, and designing mounting interfaces, which allows them to focus on their expertise: device manufacturing, high throughput screening, or packaging.

TCO Applied to Linear Motion

The Total Cost of Ownership principle was first defined in the 1980s to quantify the cost of implementing personal



Some linear motion companies have begun offering complete, pre-configured Cartesian motion systems, such as the Rexroth camoLINE, to save users time and money in the implementation of Cartesian robotic systems.

A typical belt-drive linear actuator, the Rexroth MKR, provides higher speeds and longer lengths than typical screw drive actuators. Screw drive systems offer higher precision and higher load capacities.

computers in the workplace. Since then, TCO theory has been applied widely throughout all major industries, including manufacturing, to analyze the lifetime costs of major assets. A well-implemented Cartesian robot or other multi-axis manufacturing system, for example, can not only cut production time and increase throughput, but can also improve quality and profits. If poorly implemented, however, those profits can disappear in re-work, re-design, or unexpected maintenance costs.

In our car example, we evaluated the ongoing costs of running and maintaining the vehicle as important considerations beyond the initial purchase price. But what factors should you consider when evaluating the costs of a linear motion system? In this case, unplanned or infrequently considered costs are often found in three separate phases of implementing the system.

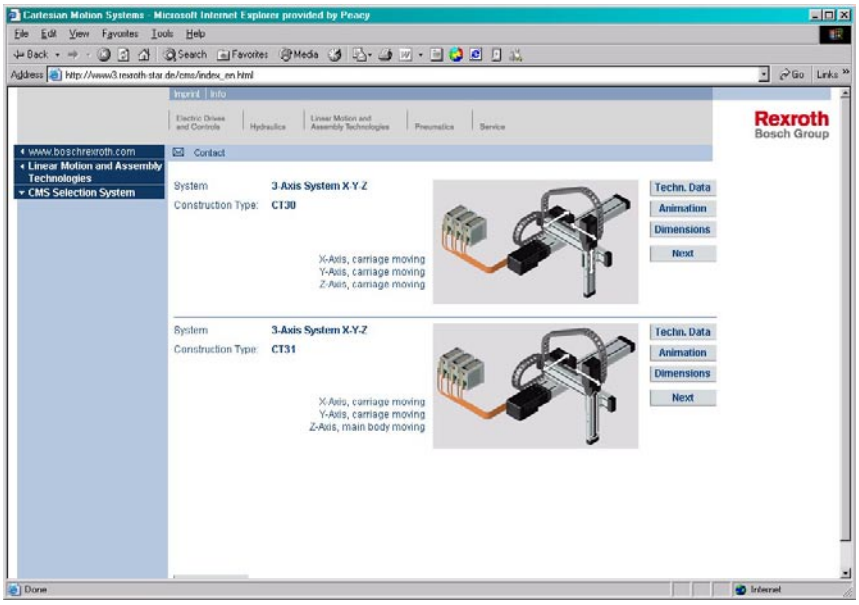
- Pre-purchase activities such as design and specification.
- Purchasing, which includes

ordering, taking delivery, system assembly and startup.
- The post-purchase phase, including maintaining and re-purposing your system.

The Pre-Purchase Phase: The critical starting point

The pre-purchase phase is the most important phase of implementing a linear motion system. In this phase, the cost elements influencing TCO depend on the time required to design, specify, and purchase the appropriate linear motion system. Making good choices in the pre-purchase phase can save time in designing the system and in sourcing the components. Getting it right early also ensures smooth startup and trouble-free operation. With good planning, it's possible to save some money here without causing trouble later.

The key to success in this phase is sizing and selecting the appropriate linear module or modules for your system. To make the sizing and selection process easier, most reputable linear motion companies offer considerable resources in web-based sizing and selection tools. A typical three-axis Cartesian system normally requires at least 17 hours of engineering time just to size the system to ensure you're getting the right modules to handle the application requirements—not undersized or oversized. For example, laboratory automation often calls for smaller systems. If the system is larger than the application requires, you've wasted both money and space.



Online sizing tools, like Rexroth's CMS configurator, take much of the guesswork out of selecting the right modules for the overall system. The Rexroth website features many such tools at www.boschrexroth-us.com/tools.

Good sizing tools can guide the user through the main factors that need to be considered, and can cut this time to three hours or less. Coupled with automated drawing generators, which provide instant access to 2-D and 3-D models even for complex systems, the user can save $1,120 or more in engineering costs alone (see Table 1).

Cost savings resulting from good planning go well beyond saved engineering time. Consider the consequences of a poorly engineered system. A system that is not robust enough to handle the application, if installed, leads to terrible waste due to poor performance, lost productivity and lost revenue from missed market launch opportunities. In addition, factor in the extra cost and hassle of removing the ineffective system, re-sizing the application, re-ordering, re-installing, and starting up a new system. The wasted time and money involved can easily exceed thousands of dollars and, if you are a machine builder, may cost you a lost customer.

The Purchase Phase: That red tape is expensive

Once the linear motion system is selected and designed into the application, purchasing activities begin. Some companies can provide a single part number for a complete, multi-axis electromechanical system, making the ordering process easier by simply reducing 20 or 30 part numbers down to one. The result: Savings in the number of vendors, purchase orders, and line items, further leading to time savings throughout the approval, procurement and receiving processes. At $100

processing cost per purchase order, savings could add up to another $2,000 or more per system (see Table 1). And if you need to order a duplicate system, repeat cost savings are already built in.

After the linear motion system is received, a significant amount of time can be spent assembling and starting up the system. To reduce cost at this stage of the product life cycle, it is important to choose a system that is easy to install and does not require complex start-up procedures. Pre-assembled linear modules and Cartesian systems offer the least complexity in this regard, as 80 percent of the assembly, integration, and programming work is done by the manufacturer. Recognizing these cost savings, many system integration companies are using pre-configured Cartesian systems to cut their costs and lead times and, as a competitive edge, are passing those savings along to their end-users. In conjunction with pre-assembled systems, user-friendly Human Machine Interfaces (HMIs) and programming protocols can save still more time and money by providing machine-builders and end-users with simple open-based programming options.

The Post-Purchase Phase, or: What does "Lubed for Life" mean, exactly?

After the system is put into service, maintenance work can add several thousand dollars to the cost of ownership over the life of the system. This is a key area often underestimated by machine designers (and the purchasing department). Some linear products are cleverly marketed as "lubed for life." However, it is important to note that the life (number of meters or revolutions traveled) is often defined with no load applied to the system. Be sure you understand the manufacturer's "fine print." When a load of just

Table 1

			Custom-Built System		Pre-Built System	
	Activity	Cost ($/hr)	Time (hrs)	Total Cost ($)	Time (hrs)	Total Cost ($)
Design	Concept	80	4	320	1	80
	Design	80	8	640	0	0
Engineering	Size and Select Products	80	3	240	0.5	40
	Issue Requests for Quote	80	0.5	40	0.5	40
	Evaluate Quotes	80	2	160	1	80
Purchasing	Create Bill of Material	30	2	60	0.5	15
	Enter Part Numbers	30	3	90	0.5	15
	Receive and Uncrate Products	30	2	60	0.5	15
Engineering	Assemble	60	8	480	0.5	30
	Test	60	2	120	1	60
	Debug and Modify	60	4	240	0	0
	Re-test	60	2	120	0	0
	Run-in	60	4	240	1	60
			44.5	$2,810	7	$435
	Savings of Pre-Built vs. Custom-Built System				84%	85%

100 pounds is applied, the life of these "lubed for life" components can be reduced by five times, for example, from 25,000 km to 5,000 km. For a machine with 1-meter stroke, traveling at 1 m/s for 16 hours per day, this equates to approximately one full year of life that is lost. If the scheduled replacement of the linear motion system is every three years, then a lost year of life increases the replacement frequency by 33 percent.

To reduce maintenance or replacement costs, choose a linear motion system that incorporates full contact seals, which preserve lubrication inside the moving components and prevent contamination from entering. Re-lubrication time and effort can also be reduced by choosing a system with easy-to-access lube ports or the capability of using an automatic lube system. The maintenance personnel will appreciate such a design.

Beyond lubrication and preventive maintenance, it is sometimes necessary to repair or upgrade a machine in order to increase performance, which often involves changing or upgrading the linear motion system. In many cases, the entire linear system does not need to be upgraded or replaced—just one or two components. Some manufacturers of linear products make it easy to replace only a part of their system by offering interchangeable components—profiled rails and runner blocks, for example. This reduces not only the cost of the parts that are needed, but also the time required to make the changes in the machine. With interchangeable components, the cost of replacing or upgrading a linear motion system can be reduced by 75 percent, for example, if only the runner block needs to be replaced, and not the profiled rail.

TCO puts low price in context

Today's manufacturing environment is increasingly defined by lean initiatives—to cut waste wherever possible. But lean thinking is frequently deployed to re-organize manufacturing processes only. As we've seen, cutting waste to optimize TCO can occur at every phase of a capital equipment project. Everything from your initial research and design, through acquisition and startup costs, and finally the operation and maintenance of your system, contributes to your total cost of ownership.

Interchangeable components make it easier to effect repairs by allowing end users to replace just a block on a linear rail instead of having to bolt down an entire matched set. Rexroth eLINE, shown here, even lets users switch from cam roller blocks to standard eLINE blocks.

Look beyond just the price provided on the vendor's quotation and consider the costs associated with specifying, designing, purchasing, and maintaining the system. The short-term savings achieved by simply buying the products with the lowest initial purchase price are quickly eclipsed by unexpected costs that arise in these other areas. Achieving manufacturing excellence, eliminating waste, improving worker satisfaction, enhancing revenue and profits, and increasing quality can all result if TCO considerations are applied when specifying and buying manufacturing technologies.

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