



Automated Storage/Retrieval and Return/Sorting Systems

By Richard W. Boss

While librarians don't like to think of libraries as warehouses for books, there are a number of technologies developed for warehouses that can be beneficially used in libraries. Among these are automated storage/retrieval systems (AS/RS) and return/sorting systems, collectively known in the warehousing industry as materials handling systems. When used in libraries, the former technology consists of computer-driven robotic retrieval of densely stacked storage bins, thus cutting down on the amount of space required to house a collection. The latter consists of book drops, conveyors and multi-bin , tote, cart, or book truck sorters that cut down on manual handling of books and other library materials being returned. A variant of the latter handles return and sorting at a self-contained patron self-service unit that handles check-in and limits sorting to items to be reshelfed and those that have reserve requests against them.

The AS/RS installations in North American libraries are all in academic libraries because these libraries have very large collections, a significant percentage of which are infrequently circulated. However, several score public libraries with research collections or extensive special collections should consider the technology. A number of public libraries in Europe already have.

The majority of known large return/sorting systems in North American libraries are in public libraries because their circulation figures are very high in comparison to academic libraries, especially in relation to collection size.

Both technologies are cost effective only in relatively large libraries. A basic AS/RS system stores up to 400,000 items, although most are initially loaded with only half that number of items when first installed. The largest installed system as of the second quarter of 2008 had a capacity of two million items. A large return/sorting system that handles 250,000 or more returns a year is cost effective, but libraries with smaller circulations can cost-effectively utilize patron self-service return units with limited sorting capability.

AUTOMATED STORAGE/RETRIEVAL SYSTEMS

An automated storage and retrieval system (AS/RS) is designed to store lesser used materials in a minimum of space by eliminating stack aisles, storing materials by size, and using building volume more efficiently.

Items to be stored are assigned to and placed in a bin according to size, and each bin is assigned a location. The bins are then placed in an industrial rack assembly. A large assembly may be up to 50 feet high and 90 or more feet long. A computer-controlled mini-load crane (an electrically-driven forklift-like mechanism running on floor-mounted and overhead rails in the space between racks) moves into and out of the rack assembly removing and replacing bins. When an item is requested, the bin location is sent to the mini-load crane, which retrieves the bin and carries it to the operator. The operator, guided by a visual display on a PC-based workstation, takes the item from the bin and places it on a conveyor or in a pneumatic tube for delivery to the service desk.

Elapsed time for retrieval from the AS/RS is from one to ten minutes, but, by taking advantage of the data maintained by the computer, high-demand items can be moved to the front of the rack assembly after they have been used and returned, thus minimizing retrieval time. In a library application, 40 retrievals per hour per operator is common, but it can be as high as 100 if everything which has circulated recently is in the nearest bins. [Few of the libraries using AS/RS report an average of more than 170 retrievals a day]. Returning the item to storage follows the same procedure in reverse and requires a comparable amount of time.

Benefits

There are several benefits to AS/RS Technology, among them low storage space requirements, high patron success rates, good collection preservation, and low ongoing costs.

Storage Space Requirements

The major benefit of AS/R technology is a dramatic reduction in library materials storage space. Storage of 400,000 books and book-equivalents requires no more than 2,000 square feet as compared with 40,000 square feet using conventional shelving. The "fullness" of the shelves can have a negative impact on the management of materials in open stacks. At 85 percent full, it is increasingly difficult to reshelve items and keep shelves in order. Periodic shifting of the collections makes significant demands on staff time. In contrast, there is no negative impact related to the "fullness" of an AS/RS bin-even at 100 percent.

High Patron Success Rate

The "success rate" of patrons is increased when AS/RS technology is used to store books and other library materials. . The success rate is the percentage of materials sought that a patron is actually able to locate. It is the product of the "holdings rate" and the "availability rate." A library with extensive holdings may have 90 percent of what patrons seek in the catalog, but if only 70 percent of the catalog holdings can be found, the success rate is only 63 percent. On the other hand, a library with a

holdings rate of 80 percent and an availability rate of 90 percent would make patrons 72 percent successful.

A major factor in achieving a high availability rate, and thus potentially a high success rate, is the availability of materials either in the AS/RS or identified in circulation records as outstanding to a known patron and subject to recall or reservation.

Any open access approach is subject to items being out of order as the result of re-shelving by patrons, the intentional misplacement by patrons seeking to restrict access to all but themselves, or even theft. Since patrons do not have access to the AS/RS and the system retrieves only the bin in which the inventory shows the item is to be housed, there is virtually no chance of losing track of an item.

Collection Preservation

A collection must be protected not only against theft, but also against heat, humidity, and seismic activity. Heat and humidity can be controlled by a properly adjusted HVAC system but any collection open to patrons must be controlled within a range comfortable for humans, 65-75 degrees and 40-60 percent humidity. Areas closed to patrons can have the temperature reduced to 50 or lower and the humidity to 30 percent, thus extending the life of the materials. Each degree below 65 adds at least a year to the life of printed materials.

The extent of seismic damage is very much dependent on the strength and flexibility of the shelving or other storage equipment. Bracing is necessary to limit lateral movement and crossbars to reduce the risk of the domino effect if one unit topples against another. Theoretically, an AS/RS is structurally better able to withstand seismic activity than conventional open stack shelving. That was confirmed in the earthquake that struck the University of California at North Ridge. The system sustained only minor damage, and no books were damaged. A considerable amount of conventional shelving collapsed and even that which withstood the quake spilled large numbers of books into the open aisles between ranges.

Low Long-term Costs

All costs in this section have been collected by the author in his capacity as a consultant to libraries investigating and/or implementing AS/RS.

The cost of constructing and equipping a library's stacks area is approximately \$20 per volume; the cost of constructing and equipping an AS/RS is approximately \$4.00 volume, however, this difference is realized only if an AS/RS accommodates at least 400,000 volumes.

The ongoing cost for maintaining the space required for an AS/RS is also lower. For example, the cost of maintaining 2,000 square feet of space with a ceiling height

of 40 feet (HVAC and custodial) is approximately \$16,000 per year. The custodial cost is low because the area is small and not open to the public; the HVAC cost is slightly higher because the great ceiling height and stricter temperature and humidity controls. In contrast, the cost of maintaining 40,000 square feet of open stacks space is approximately \$60,000 per year.

Maintenance of the equipment for a system requiring 2,000 square feet of space costs roughly \$10,000 per year, plus an allowance of about \$2,500 per year for computer replacement. In addition, an onsite technician is highly desirable. A technician will cost over \$45,000 per year (including 23 percent for fringe benefits).

An AS/RS will require at least one operator each hour a library is open. One should also assume that peak activity will be up to three times the average, therefore, requiring two or three operators during some hours. Assuming that the materials in the AS/RS have been selected on the basis of low frequency of use, it is likely that no more than 15,000 retrievals per 100,000 volumes will occur each year. Open stacks circulation averages as high as 200,000 circulations per 100,000 volumes. Assuming as many as 60,000 retrievals and 60,000 "rebinings" in a year in an AS/RS collection of 400,000 volumes, it would take at least 6,500 hours of staff time to handle the workload. The actual number of hours might be somewhat higher because of peaks and valleys in the activity. If one assumes 8,000 hours, the cost for 8.0 FTE (full-time-equivalent) staff would be \$88,000 per year—a figure that assumes an hourly cost of \$11.00.

While the open stacks shelving itself will require very little maintenance or repair for twenty or more years, reshelving, shelf-reading, and shifting will require a minimum 28,000 hours a year (14 FTE) at a cost of \$11.00 an hour—a total cost of \$160,600 a year.

Drawbacks

There are a number of drawbacks to AS/RS technology, including perceived risk of investing in an unfamiliar technology, loss of "browsability," inappropriate selection, and inadequate prompting.

Perceived Risk of Investing in an Unfamiliar Technology

An AS/RS with a capacity for 400,000 volumes (books and book-equivalents) requires a system with at least three cranes aisles, six end-of-aisle workstations, 4,000 bins, and an electric track vehicle delivery system. The start-up cost will be as high as \$1,000,000—a figure that includes a conveyor or mechanical delivery system between the AS/RS and a public service desk.

While there is considerable disagreement among architects about the cost of building a 40-foot high chamber with a floor-loading of 300 pounds per square foot,

the median cost quoted by the few architects who have experience with AS/RS is \$250 per square foot, plus the cost of the AS/RS. The total space needed to accommodate 400,000 volumes is as much as 2,000 square feet; thus, the space would cost at least \$500,000, bringing the total capital outlay to \$1,500,000.

The cost of building and equipping 40,000 square feet of open stacks space for 400,000 volumes would be approximately \$7,000,000 if one assumes a cost of \$175 per square foot.

While investing \$1,000,000 or more in the addition of space and equipment for open stacks is virtually risk free, there is a perception that investing that amount of money in a technology that is not very well known is risky. Librarians have committed that much money only to bricks and mortar and well established technologies such as integrated library systems and electro-mechanical compact storage.

Lack of Browsability

"Browsability" is the opportunity to browse the shelves to look not only for that which has already been identified, but for related materials. This serendipitous discovery factor is important to many patrons. On the other hand, many patrons would like to limit the retrieval time. They want to obtain a few titles quickly.

Unless a library makes a good case for the use of AS/RS, the decision to install it can be controversial.

The quality of bibliographic access is always an issue, but particularly so if patrons cannot examine materials on the shelves. Even a catalog that conforms to the Anglo-American Cataloging Code II does not answer all questions a person searching the catalog may have. For example, one California State University at Northridge faculty member interviewed by the author was using materials written in Greek and the online patron access catalog was, in his opinion, not complete enough for him to determine if a book was the translation of a specific edition he was seeking. In an open access environment, he would go to the stacks to examine materials and browse, but in a restricted access environment the catalog must substitute both for known item look-up and for browsing in the stacks. He was unaware that there was no limit on the number of items he could request from the AS/R and that the staff had been instructed to make no comments about a request for a large number of items.

If the bibliographic records were to include links to the tables-of-contents of monographs, the need for browsing would be substantially reduced.

Inappropriate Selection

An obvious choice for an AS/RS are materials which have not circulated for a long time, but equally suitable are materials not traditionally subject to browsing in open

stacks such as bound volumes of journals. The greatest source of frustration for patrons is the storage of very popular materials in an AS/RS. Rather than finding best sellers on special display racks or in the open stacks, patrons must submit a special request.

The return to the open shelves of materials which circulate two or more times in rapid succession from the AS/RS has been an effective way of limiting patron frustration.

Inadequate Prompting

It is essential that there be well-designed prompt screens in the online patron access catalog to alert users to the fact that an item is readily available onsite in an AS/RS, subject to request and retrieval in a matter of a few minutes. When the prompts are inadequate and patrons go to the open shelves looking for materials, there can be a serious public relations problem.

Mechanical Failure

The life expectancy of an AS/RS is 30 years or more, although moving components will require regular servicing, and replacement of computer equipment should be anticipated at least seven times during this lifespan period. Mechanical failure will occur, therefore, it is essential that library staff be able to handle most problems. Ideally, a library would have an AS/RS technician on staff.

Materials that cannot be retrieved because of mechanical failure of retrieval equipment are worse than lost as patrons may blame the library staff for the failure.

The 98 percent reliability level of AS/RS systems-is high by most standards but, in a library open 100 hours per week, the loss of access two percent of the time could be up to two key hours during the week. However, most of the downtime consists of jammed or misaligned bins; a problem staff can fix within minutes by merely giving the robot a different address past the problem point. That allows the technician time to schedule his/her work so that the most critical problems are addressed first.

Major Manufacturers

While more than a dozen companies manufacture AS/RS equipment, only one, H.K. Industry, is known to have targeted libraries. It has a separate URL for its library product (www.automatedlibrarysystems.com). The description of the technology in this TechNote is, therefore, based on its product--one that has been installed by a number of libraries in North America, including the University of California at Northridge in 1991, a system with a capacity for more than one million books; the University of Nevada at Las Vegas in 2000; and subsequently Eastern Michigan University; Sonoma State University; Chicago State University; Valparaiso University; University of British Columbia; Santa Clara University; Colgate

University; University of Louisville; Long Beach State University; and the University of Utah. The last has 19,173 storage bins that can accommodate more than two million volumes. [Contact: HK Systems, 2655 St. James Drive, New Berlin, WI 53151, Telephone 800-424-7365, fax 262-860-7014, Web: www.hksystems.com].

Another major manufacturer, FKI Logistex of Denmark, is interested in the library market. While it has focused on the sale of conveyor/sorting systems through distributors, including integrated library system vendors, it manufactures an AS/RS quite similar to that of HK Systems. For 2008, it booked exhibit booths at six library conventions, including the Public Library Association in March of 2008.

[Contact: FKI Logistex North America, 9301 Olive Blvd., St. Louis, MO 63132, Telephone 877-935-4564, Web: www.fkilogistex.com].

While none of the other major manufacturers of AS/RS have pursued the library market, a library may want to investigate AS/R Systems (www.asrsystems.com), Dematic (www.dematic.com), Remstar (www.remstar.com), and Viastore (www.viastore.com).

RETURN/SORTING SYSTEMS

Return /sorting systems—the library community’s term for what are called “conveyor/sorting systems” in industry— move materials from the point of return to sorting equipment that can scan barcodes or RFID tags to ascertain onto which of several bins, totes, trolleys (carts that accommodate a single stack that can be tilted at any one of several angles), or special book trucks an item should be dropped. While there are scores of manufacturers of such systems for warehouses, libraries have been most interested in companies that also offer book drops or patron self-service discharge units that front-end the conveyor to reduce handling and that interface with an integrated library systems for automated check-in and the re-activating of security tags.

The front-end can be a book drop that drops returned materials onto a conveyor for transport to a sorter or it can be a return unit that handles the actual check-in by straightening the items and scanning barcodes or tags as they drop, sending the information to the interfaced integrated library system, and sorting the items into two bins for returns and reserves. Optionally, twin conveyors can move the items to another location, even to a larger back-end sorting machine..

The former approach can handle much high return rates per book drop because patrons do not have to position and/or drop items one by one, and there is no delay getting items onto the conveyor. While it reduces the cost of having several expensive return units, it requires relatively expensive high-volume sorting equipment to deal with the flow from multiple book drops.

The latter approach can be used with back-end sorting equipment, but is more often used for a simple two-part sort in smaller libraries that only need a few book drops.

Patron self-charge/discharge units can be used with a return/sorting system, but are not included here because they are very familiar to librarians. Thousands of libraries are using them. For those who need information about them, the best sources are the Web sites of Libramation (www.libramation.com) 3M (http://solutions.3m.com/wps/portal/3M/en_US/library/home/products), Vernon Library Supplies (www.vernonlibrarysupplies.com/cgi-bin/vernlib.cgi/XPRESS), vendors of return/sorting systems, and vendors of integrated library systems.

For libraries with large circulation volumes, a minimum of 250,000 returns a year, the more expensive back-end sorting equipment is more cost effective. Because it can be configured with scores of bins, totes, carts, or book trucks; items can be automatically sorted by location, including locations in branches and other libraries. This dramatically reduces staff time.

Wheeled bins have the greatest capacity, as many as 200 items each; totes can accommodate as many as 25, as many as most staff can lift; trolleys at least 30; and special book trucks as many as 50. The advantage of book special trucks is that they can be used for reshelving. However, much more complicated sorting equipment is required to place items on a special book trucks as opposed to dropping them in a bin or tote, or onto a trolley that takes a single vertical stack.

Benefits

The greatest benefit of return/sorting systems is the reduction in ongoing operating costs as the result of a significant reduction in the handling of returned items by library staff. Staff members do not have to empty book drops, move materials, check them in, re-activate the security tags, or place them in bins or totes, or onto trolleys or special book trucks. Anecdotal evidence suggests that the initial investment can be recovered in reduced labor costs in as few as four years. However, most libraries utilize the savings by redeploying library staff to direct customer service.

Another benefit is that materials are ready more quickly for reshelving, thus increasing the availability of materials.

Finally, the use of return/sorting systems reduces the incidence of repetitive motion injuries for staff.

Drawbacks

Relatively high start-up cost is the greatest drawback to return/sorting systems. Return/sorting systems typically cost a minimum of \$150,000, including conveyors.

Such a system would have no more than five bins, among which might be adult, children's, A-V, and reserves. The fifth usually is a "reject" bin for items that the sorter cannot categorize. A 60-bin system would cost a minimum of \$1,500,000, including a significant conveyor component.

Manufacturers

Three major manufacturers of return /sorting systems were pursuing the library market as of the second quarter of 2008: FKI Logitex Crisplant, MK Sorting Solutions, and Tech Logic. The first two companies, both based in Europe, had North American distributors, but also periodically respond to RFPs for large systems sought by libraries. Codeco, which was active in North America for several years, was focusing its efforts on Europe and Australia as of the second quarter of 2008.

FKI Logistex

While the Danish multi-industry provider of conveyor and sorting systems has an office in the United States, it serves the North American library market through distributors for small return/sorting systems. The primary distributor as of the second quarter of 2008 was Integrated Library Systems (www.inegratedtek.com) While ITG offers some FKI Logistex return components, most of its products are of its own design and/or manufacture. However, the conveyors and sorting components are those of FKI Logistex's Crisplant subsidiary. There are two models of the FKI Logistex Crisplant Library Mate system, the simpler is a two-bin sorter that can sit behind a book drop and allow items to be automatically checked-in and to have RFID security tags turned on. The book drop can be incorporated into patron self-service charge/discharge unit. At a green signal light, a patron returning an item at the unit must feed books one at the time into a slot. The items then pass through a short conveyor with an RFID reader (and/or barcode reader) and built-in antenna that interfaces with the integrated library system. There are two bins, one for reshelving and one for items that have reserves against them, the tags of which are unreadable, or that do not belong to the library. A printed receipt can be issued at the option of the library. Staff is signaled when a bin is full.

The larger system, of which the company has installed approximately 800 worldwide for a number of industries, performs the same functions, but has a more extensive conveyor system known as the Crisplant Compact Sorter that leads to a multi-bin configuration that can sort items by library location, including branches and other libraries. The largest installation in a library is the four return/71-bin system at the Aarhus Library of Denmark. It can handle up to 4,500 items an hour.

As mentioned in the first section of this TechNote, FKI Logistex also has an AS/RS system.

[Contact: FKI Logistex, 9301 Olive Blvd., St Louis, MO 63132, Tel. 877-935-4564, Web: www.fkilogistex.com/library or Crisplant, 4612 Navastar Drive, Frederick, MD 21703, Tele. 240629-1413, Web: www.logistex.com/christplantinc]

MK Sorting Systems

MK is a German manufacturer of patron self-charging and discharging equipment, return stations, and conveyor/sorting systems. It sells all but its very large conveyor/sorting systems for libraries through distributors. As of the second quarter of 2008, the exclusive North American distributor was Libramation, a company that was once a distributor for Codeco.

The interfaces between the products and an integrated library system have been developed by Libramation.


There are two sorting equipment options, a two-way sorter and a three-way sorter. The first sorts into just two bins or onto two conveyors; the second sorts into as few as three bins, with two-bin modular expansion to five, seven, nine, and even more bins up at least 200. The system can be configured to drop materials into bins or place them onto trolleys. However, bins accommodate at least 180 items and trolleys no more than 28.

[Contact: MK Automation Inc., 105 Highland Park Drive, Bloomfield, CT 06002, Tel. 860-769-5500, Web: www.mk-sorting-systems.com or Libramation Library Systems, 12527 129 Street, Edmonton, AB, Canada T5L 1H7, Tel.888-809-0099, Web: www.libramation.com].

Tech Logic

Tech Logic offers patron self-discharging units, but the focus of this TechNote is complete return/sorting systems. Tech Logic's "Ultra Sort" return/sorting system moves books and other library materials from wall or counter-mounted return drops or patron self-discharging units via conveyors to machinery which squares the books and other library materials, scans the barcode or RFID labels to discharge them, re-activates the security tags, and rotates and places them on special book trucks ready to be reshelved or into ergonomic bins, units that are self-leveling so that staff do not have to bend over to remove materials. A "Quick Sort" system that is limited to a book return conveyor and three or five bins or totes is available as an option. It uses low-cost bins or totes.

The Greensboro Public Library of North Carolina was the first North American library to install a Tech Logic return/sorting system in late 1998. Subsequent customers include the public libraries of Boulder (CO), Carmel (CA), Council Bluffs (IA), Dakota County (MN), Eugene (OR), Hennepin County (MN), and



Topeka (KS). The company's largest installation is at the Seattle Public Library. That system that includes a 72-bin sorter for the main library, plus a 40-bin sorter for interagency movements of materials. The contract, which totaled \$5.7 million, also includes a migration to RFID for all 40 agencies.

[Contact: Tech Logic Corporation, 1616 Gervias Avenue, Maplewood, MN 55109-2128, Telephone 800-494-9330, fax 651-747-0493, W www.tech-logic.com].

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