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Aimée C. Quinn
Central Washington University, aimee.quinn@cwu.edu

Michaelyn Haslam

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Storage of growing collections is an ongoing problem for libraries. Past attempts at using the industrial solution of automated storage and retrieval systems (AS/RS) ended in failure. However, improvements in these mechanisms, especially computer control and the ability to interface with online library catalogs, make them a viable option for libraries. Questions remain about the appropriateness of treating intellectual material like industrial parts. In addition, access is still an issue especially in regard to government depository documents. A literature review shows that while there is a tremendous amount of research available on the design of AS/RS, little is written about its application in libraries.

Even with the rapid change of document formats from paper to electronic, the necessity of housing growing collections of print materials continues to be a problem for depository libraries. This article discusses the case of a depository in an academic library where a new library facility is being built that significantly reduces the space allocated for documents. The plans for the building include an automated storage and retrieval system (AS/RS) where less used materials from all parts of the collection, including the depository, will be stored. The use of AS/RS in industry and in libraries is examined along with the challenges facing the library to prepare materials for this unique storage facility.

HISTORY OF AUTOMATED STORAGE AND RETRIEVAL SYSTEM USE IN INDUSTRY

Industry started using automated storage and retrieval systems (AS/RS) in the 1950s for warehousing raw materials, parts, and end products. As the AS/RS proved effective, their

* *Direct all correspondence to: Aimée C. Quinn, University of Nevada Las Vegas, Library, 4505 Maryland Parkway, Box 457001, Las Vegas, Nevada 89154-7001 <quinna@nevada.edu>.*

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use has been expanded in advanced manufacturing systems where, in addition to the warehouse function, they are integrated into the production process. An AS/RS system consists of storage aisles with metal frames for housing bins or pallets rising up on both sides. The bins or pallets contain parts or materials. A retrieval mechanism for each aisle pulls out the selected bin or pallet, then takes it to a pickup and delivery station at the end of the aisle. From there, the material handling system, often conveyor belts, takes the item to the next stage of production or delivery point. As parts are needed from the AS/RS, conveyors take them to the point of production. Integrated computer systems determine the needs of a job and direct the AS/RS to retrieve and deliver materials to where they are needed. At each stage of the process the product can be stored by the AS/RS or moved along to the end of production where the final product can be stored. AS/RS have proven to be efficient and cost effective. They save labor costs, enhance material flow, provide inventory control, increase safety, and improve stock rotation.[1] Investigation into the use of AS/RS for libraries indicates that they provide an on-site alternative to remote storage, fit more material into the same amount of space as compact shelving and offer the cheapest cost of storage per book.[2] Libraries and industry share similar goals including saving labor costs, enhancing material flow, maintaining inventory control, assuring safety, and facilitating access to materials.

At the same time, a number of differences between industry and library functions raise questions about the appropriateness of storing intellectual material in a warehousing facility. Industry constantly rotates through the three warehousing functions: receiving, storage, and retrieval. Libraries have a proportionately small amount of receiving after initial load, with more emphasis on storage and retrieval. Since libraries store low use material, the storage function is emphasized though retrieval is crucial. Industry expects turnover whereby all items will be retrieved and replaced by like or newer items while libraries will house the same materials indefinitely, continually adding more. Industry has more control over the flow of materials and can base priorities on production requirements or due dates.

In libraries there is no consistent way to predict use of materials accurately, compounded by the fact that the stored materials are defined as low use. Priority schemes used in inventory control such as "First In, First Out" (FIFO) or "Last In, First Out" (LIFO) do not apply to the library situation because, again, use is unpredictable. Industry can zone locations to distribute high use items for quickest retrieval.[3] A library can zone based on types of material such as periodicals or government documents or by zoning specific subject matter or even by classification, but the result will not necessarily aid in the retrieval of requested items. Industry can store like items in multiple locations to increase retrieval options while in libraries, each item is unique and can not substitute for another.

INTELLECTUAL CONTENT AND INDUSTRIAL STORAGE

In the industrial world, AS/RS facilities store interchangeable materials such as nails, nuts, and bolts.[4] While this technology is admirable for industrial parts, what about storing books in these bins? Does storing materials inhibit their use or indicate they are worthless? What kind of message, if any, does a library send when materials are weeded and stored? The debate on this issue is complicated by the insistence of many scholars to treat books differently from any other commodity. One of the most common arguments against storage

is that it destroys browsability and prevents serendipitous discoveries which help make research rewarding.

Should knowledge, found in books, be treated the same as any other tool? On a more basic level, is knowledge a tool? If so, then it should be stored as any other tool. If not, where should libraries turn to find adequate space to store the growing world of knowledge? These questions are part of a larger debate regarding the migration of full-text to the Internet. In a sense, the Internet is related to the AS/RS by having the electronic world of knowledge stored at a variety of servers across the country. Remote servers around the world store digitized knowledge causing a person to know how to find this information, where it is located, and then how to utilize it. These same characteristics mark the AS/RS. One example of this trend is the Library of Congress which is working frantically to digitize many of its collections in order to open the doors to a wider clientele.[5]

AUTOMATED STORAGE IN LIBRARIES

In the early 1970s, AS/RS facilities were built in five libraries; the first was in Rotterdam, Netherlands and the other four in the United States. Two large academic libraries were involved, Erasmus University in Rotterdam and the Medical Sciences Library at Ohio State University. The other U.S. facilities were at one community college library and at two public libraries. All five purchased the Remington-Rand Randtriever system. However, only the Randtriever at Erasmus University was considered a success. The U.S. systems have all been abandoned with the space converted into room for stacks, compact shelving, offices, and classrooms.

The conditions for failure were present from the outset. With only four orders, Remington-Rand backed out of production after realizing there was a small market for this product which required custom-made equipment. Manufacture of the four U.S. systems was subcontracted. Problems persisted in manufacture and operation. Lack of technical support, including maintenance, contributed to frequent downtime which severely impacted service. By 1985, three of the four U.S. facilities had closed down. Ohio State University, the fourth site, decided to end operations in 1989.[6] The fifth system, at Erasmus University, required extensive upgrading to make it and keep it functional. The university took complete responsibility for the system after the manufacturer withdrew. Several actions were necessary to make the system workable such as installing safety devices, replacing communications systems, converting to computer control, and linking to the library's circulation system. All of the changes took place over a period of several years and resulted in a fully operational system.[7]

Nevertheless, the reasons for adapting this technology to libraries still exist. Over the past decade, industry accepted and improved upon AS/RS, making technical advances in equipment and systems operations. These advances include the ability to integrate AS/RS operating software with online catalogs thus allowing users to request materials electronically. Linking the two software programs allows users to search the online catalog, locate the material they wish to use, and order the item from storage while still online. As soon as the item is ordered, the retrieval mechanism is activated and the bin with the item is delivered to a technician at a pick-up and delivery station. The technician, notified by the system of the item requested, takes the item from the bin and sends it to the circulation desk where

it is held for the requester. The entire transaction takes less time than for the average user to look up the material, find the item on the shelf, and go to Circulation to check the material out. In fact, some libraries are re-examining this technology with renewed vigor. California State University (CSU) at Northridge successfully adapted an AS/RS faciltiy in its plans for expansion of the main library in 1991 with a facility capable of holding up to 950,00 volumes.

CSU Northridge was able to take advantage of the improvements made by industrial developments in AS/RS.[8] Many of the features which Erasmus University added to its system, including computer control and linking with the circulation system, were integrated in the CSU Northridge facility. CSU Northridge staff estimates the average time of an AS/RS transaction is under 10 minutes while a manual transaction can take up to 20 minutes. Mechanical maintenance has not been a problem though the company which installed the AS/RS merged with another. Software support was an issue as the programmer who developed the AS/RS system software left the company leaving no one else to make computer code changes that would enhance operation. Overall, CSU Northridge has been satisfied with its AS/RS and reports that, after some initial resistance, both campus and community users are happy with the system.[9]

AS/RS AND THE UNIVERSITY OF NEVADA LAS VEGAS

The University of Nevada Las Vegas (UNLV) is celebrating its 40th birthday in 1998. In spite of being a young university, the Libraries collections are growing. Increased funding by the Legislature over the past several years allowed the Libraries to increase subscriptions to serial titles. A strong, but relatively small, undergraduate monograph collection is being enhanced with purchases of major microfilm sets and more research collections. In addition, UNLV has an extensive federal depository collection of over one million items. While planning a new library building, the former Dean of Libraries had seen the AS/RS in use at CSU Northridge and was intrigued by its potential. Learning that this technology had not been an integral part of planning a new facility, the Dean presented a proposal to incorporate this technology into the new building footprint. Selection criteria for materials to be located in the facility were tabled until the state Legislature provided the funds to complete the building. During the 1997 legislative session, this appropriation was forthcoming. Combining these funds with private donations paved the way for the new building with an AS/RS. Ground-breaking for the new library is scheduled for early Spring, 1998 with a target completion day of late Autumn, 1999.

SYSTEM SPECIFICATIONS

As bidding has not been completed on the construction of the new library building and AS/RS, no vendor has been contracted. However, specifications for the AS/RS, which is closely modeled on the one installed at CSU Northridge, has been documented for the bidding process. The system will open with three aisles and expansion space will be left to allow three more aisles to be added at a later time, as yet undetermined. The facility will be about three stories tall with approximately 1,300 square feet of floor space when all six aisles are complete. On either side of each aisle, storage bins are set in metal frames. Each

aisle will have 37 columns with 26 bins each. The system will have three cranes which move from one end of the aisle to the other on a track. A platform is on the front of the crane to hold a bin after it has been pulled from its metal frame. The bin is delivered to a station at the end of the aisle. At the station, a technician will manually pull the requested item from the bin and deliver it to a service window a few feet away. Patrons will pick up items at the window and then take them to Circulation or to the self-checkout system. No conveyor belts will be used in the UNLV AS/RS.

A manager computer system using IBM compatible hardware and software will run the operation. In addition to system software, a database of materials stored in the facility will be constructed. As items are selected to go into storage, the libraries' Innovative Interfaces online catalog can generate files of records to be uploaded into the AS/RS database to keep it current. The AS/RS computer system will interface with UNLV's online catalog so that once an item is identified in the catalog, an online request can be communicated to the storage facility.[10]

SELECTION CRITERIA

Although the new building at UNLV provides additional space overall, stack space is limited by the need for work space as well as additional patron space and group study rooms. Therefore, the primary determinant in material selection for the AS/RS was space. In the plans for the new building there will be room to shelve approximately five to seven years worth of bound periodicals in open stacks. This comprises about 20% of the bound periodicals estimated to be held by the library when the new building is completed. Space available to government documents in the new library will be approximately 33% or 3,000 linear feet less than in the current building. The monograph collection, which will be weeded before the move, will remain in open stacks in the new building. Since space is the limiting factor, about 80% of periodicals must be stored. Little opportunity was afforded to make decisions based on factors such as accessibility through indexes, requirements of subject discipline, or frequency of use. Instead, a uniform cutoff date will be applied to all periodicals. A tremendous amount of processing and cataloging will be necessary to ready periodicals and government documents for storage. Binding will be necessary to aid in preservation of materials. Each bound volume will have to be bar-coded and tattle-taped. Item records must be added for each bound volume. Records for government documents will have to be created in the library catalog.

The selection process contrasts with that at CSU Northridge where books which had not circulated for more than three years were targeted for storage. Books that required the least amount of work to prepare them for storage since most of the necessary processing had already been completed to make them shelfready for circulation. Other materials were determined by nature, use, format, and existence of records in the online catalog.[11] Government documents stored at CSU Northridge were non-depository items previously classed with Library of Congress call numbers. Although circulation and usage statistics were kept by CSU Northridge to determine selection of materials to be stored in the AS/RS facility, UNLV did not keep these same statistics thereby creating different criteria for selection based on space.

DEPOSITORY MATERIALS

Storage of federal depository materials is a highly charged issue in libraries if the debates on GOVDOC-L over the past two years are indicative. Many librarians resist storage of these materials citing the access clause of 44 USC (Ch. 19). Others posit the notion that the FDLP encourages libraries to treat depository items equitably with other collections and therefore, consider them likely candidates for storage. During this debate, many depositories' parent libraries are faced with multiple dilemmas including space shortages, a collection that is often times under-utilized, increasing fiscal restraints, plus the ever increasing problem of access to this vital information. One solution to all these challenges is the AS/RS. There is little research on this issue, suggesting that the AS/RS as a solution to depository space problems has been rarely articulated. However, examining the industrial uses of this facility points out the logical aspects of incorporating this technology for libraries, including depository materials.

Items consigned to the AS/RS are less subject to vandalism and will be better preserved in the climate-controlled facility. Catalog records for all items in the AS/RS should be available in the main catalog. This means that low use materials will have greater bibliographic control and will be easier to access than the more heavily used materials.[12] Providing public service to these materials may be difficult since much of documents reference is tied to the collection. For example, a librarian familiar with pulling a hearing off the shelf to find supplemental statistics will need to send the patron to the AS/RS technician in another part of the library in order to retrieve the item and have the patron look up the information for himself or herself. This approach to public service may work well for academic institutions whose mission is to teach students how to use the library, but may not satisfy the goals for public or special libraries with depository collections.

To make appropriate selection decisions at UNLV, a zero-based item selection profile of the collection was completed in mid-1997. At the same time, statistics on usage patterns were collected and an advisory group of teaching faculty and general public members was established to provide feedback on what was used or needed in classrooms across campus. Anecdotal evidence regarding use of the collection was supported by these additional studies. Consequently, materials selected for permanent housing in the AS/RS are those deemed important to keep from a historical perspective, but not heavily used for course work or by the public regularly. In addition, materials that take up great amounts of physical space, but are not used enough to warrant housing in the main collection will also be included for storage in the AS/RS. A large weeding project is currently in process. Please refer to the appendix for a list of depository titles suggested for storage.

CONCLUSION

Though library uses of AS/RS have failed in the past, significant improvements, including the ability to interface with library catalogs, point to them as a means of allowing on-site storage of low use materials. AS/RS facilities are designed for higher density storage, quicker access, and lower cost than either compact shelving or remote storage. By putting low use items in storage, time and resources can be spent on maintaining the parts of the collection that are in circulation. Accurate statistics on use can be kept. Items which circulate more than expected can be returned to the stacks or lack of circulation can be part of

the consideration for withdrawal decisions. Items in storage are more easily retrieved and are less likely to be shelved improperly. The success with improved technology at CSU Northridge bodes well for using this method of storage for library materials at UNLV. UNLV's selection of material to store was based primarily on space consideration rather than use. An enormous amount of technical processing must be done to prepare materials for storage since neither periodicals nor depository materials had ever been bar-coded. In addition, depository documents records had never been entered into the libraries' online system. Once they are in storage, use statistics will be kept to aid in ongoing storage decisions. Furthermore, storage of depository documents also raised questions of possible access barriers between the public and documents. Again, future statistical measurement will be instrumental in the success of this new facility.

APPENDIX: PROPOSED DEPOSITORY MATERIALS FOR AS/RS

~ = all holdings except the latest five years
* = materials that need preservation and may be transferred to Special Collections.

A 19 .1:	*Agricultural Yearbook*	(7 shelves)
A 57.38:	nos. *Soil Surveys*	(12 shelves)
AC	entire agency - Arms Control & Disarmament	(3 1/2 shelves)
AE 2.108/2:	*Government Manual*	(3 shelves)
~C 21.5:	*Official Gazette of the U.S. Patent & Trademark Office - Patents*	(60 shelves)
C 21.5/2:	*Index to U.S. Patents*	(4 shelves)
C 21.5/3:	*Index to U.S. Trademarks*	(3 shelves)
~C 21.5/4:	*Official Gazette of the U.S. Patent & Trademark Office - Trademarks*	(14 shelves)
C 22 - C51	all items	(16 shelves)
C 51.9:	*Government Reports & Announcements Index*	(31 shelves)
CAB	entire agency - Civil Aeronautics Board	(2 shelves)
*CC 1.12/4:	*FCC Reports*	(10 shelves)
E 1.17:	*Energy Research Abstracts*	(24 shelves)
FT	Office of Education materials	(12 shelves)
GS 4.113 & .114	General Services Admin.	(6 1/2 shelves)
HE 20.3161:	*Index Medicus*	(all volumes)
HE 20.6209:	*Vital & Health Statistics Reports*	(5 shelves)
~HE 20.6210:	*Vital & Health Statistics*	(5 shelves)
I 1.1:	*Interior Dept. Annual Reports*	(4 shelves)
I 1.94/2:	*Selected Water Resources Abstracts*	(9 shelves)
I 16	all holdings - *Report of the Commissioner of Education to the Dept. of the Interior*	(6 shelves)
I 19.8:	*Mineral Resources*	(6 shelves)
I 28	all Bureau of Mines	(63 shelves)
I 19.9:	USGS monographs	(21 volumes)
IA 1.8:	*Problems of Communism*	(3 shelves)
LC 3	*Copyright Catalogs & Decisions*	(11 shelves)
LR 1.8:	*NLRB Court Decisions*	(3 shelves)
NAS 1.9/4:	*STAR: Scientific, Technical Aerospace Reports*	(22 shelves)
NS 1.2: D 36	Proceedings: *Ocean Drilling Project Program*	(14 shelves)
~PrEx 2.8:	year *Budget of the United States*	(3 shelves)
S 1.1:	*Foreign Relations of the United States and the annual reports, messages, documents of the State Department*	(18 shelves)
S 1.71/2:	*American Foreign Policy*	(2 shelves)

S 1.82:	*Documents on German Foreign Policy*	(2 shelves)
S 3.2:	H 62/vols. *International Arbitration*	(6 vols.)
S 4.1:	*Commercial Relations*	(13 vols.)
S 5.2:	*Proceedings of the 2nd Pan American Scientific Congress*	(14 vols.)
S 7.12:, S 7.12/2:, S7.12/3:	*Digest of International Law*	(42 vols.)
S 9.12:	*Treaties and Other International Agreements (and all its other names including Bevins.)*	(10 shelves)
SE 1.9:	*Official Summary of Security Transactions & Holdings*	(6 shelves)
*SI 1.1:	*Smithsonian Institution Annual Reports*	(6 shelves)
*SI 2.1:	*Bureau of American Ethnology Annual Reports*	(3 shelves)
SI 3.1:	*National Museum Bulletins & Proceedings*	(8 shelves)
SI 4.1:	*American Historical Association Annual Reports*	(3 shelves)
T 1.1:	*Dept. of the Treasury Annual Reports*	(2 shelves)
T 12.1:	*Report of the Comptroller of the Currency*	(42 volumes)
W 1.1:	*All War Department materials including annual reports*	(6 shelves)
W 45.5:	*Report on the War of the Rebellion*	(8 shelves)
varied numbers	*Journal of the House and Serial Set*	(108 shelves)
Y 1.2:	P23 *Hind's and Cannon's Precedents of the House of Representatives*	(8 vols.)
Y 3.At 7:	Atomic Energy Commission reports and papers	
NTIS REPORTS	Entire paper collection minus NRC and YMP reading room materials	(12 shelves)

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