



## **Automated Storage and Retrieval System: a Time-tested Innovation**

**Helen Heinrich**  
Chair of Technical Services

**Eric Willis**  
Systems Administrator  
California State University  
Northridge, California, USA

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### **Abstract:**

*The Oviatt Library at the California State University, Northridge (CSUN) is the site of the world's first library Automated Storage and Retrieval System (ASRS). Born from the pilot project at the California State University Chancellor's Office, CSUN's ASRS was inaugurated in 1991 and cost over \$2,000,000 to implement. The storage facility consists of 13,260 steel bins on a rack structure that occupies an 8000 sq. ft. room forty feet high. Currently it houses over 857,200 volumes, including bins that contain archival and special collections materials. The 1994 Northridge Earthquake devastated the library building and collection, but not a single book in ASRS was damaged. Now, almost 20 years later the CSUN ASRS underwent a major renovation of hardware. The upgrade to the physical plant took more than three months to complete and had a minimal impact on library services.*

*The retrieval of materials is barcode driven. The library online catalog interfaces with the ASRS software, which maps item record to the corresponding bin. The command for the robotic crane is launched from the catalog by clicking the request button displayed within the item record. Once a request is placed, it takes 15 minutes for the materials to arrive at the circulation desk. Presently the system handles over 15,000 requests per year and the entire process is predicated on the compatibility and synchronous maintenance of the two parallel systems - the library catalog (Innovative Inc.) and ASRS software.*

*In addition to the history and overview, the presentation will discuss the major aspects of ASRS administration: specifications of storage layout and arrangement of the materials, collection policy for storing materials, communication of retrieval requests, and ASRS interface and compatibility with successive Integrated Library Systems.*

*Administrators and librarians who consider investing in ASRS will learn about the challenges of its long-term management from the example of CSUN.*

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## **Background**

California State University, Northridge (CSUN) is a vibrant, diverse university community of nearly 36,000 students and more than 4,000 faculty and staff, sited on a 356-acre campus in the heart of Los Angeles' San Fernando Valley.<sup>i</sup>

The CSUN Oviatt Library has a physical collection containing 1.4 million volumes, of which over 1.1 million are books, and over 250,000 bound periodical volumes. The Library subscribes to 57,000 online journals, over 2,300 print journals, over 200 online databases and nearly 300,000 ebooks. The archives and manuscript collection exceeds 4,200 linear feet of materials, with nearly 38,500 items housed in Special Collections.<sup>ii</sup>

## **History**

The Oviatt Library at the California State University, Northridge (CSUN) is the site of the world's first library Automated Storage and Retrieval System (AS/RS). Born from the pilot project at the California State University Chancellor's Office, CSUN's AS/RS was inaugurated in 1991 and cost over \$2,000,000 to implement. Its current annual cost of maintenance runs about \$35,000<sup>1</sup>.

In the late 1980s the California State University at Northridge Library experienced steady growth due to an increase in the number of students and faculty, an increase in the variety of academic programs being offered, that had to be supported by the library according to its mission, and the growth in the amount of printed material required to keep collections current with old and new programs.

This growth has led to inevitable space problems. By a formula CSUN Library used to calculate space needs, at that time it had a deficit amounting to 50,000 square feet a year. The conventional way of solving the space problem by adding new buildings and off-site storage facilities was untenable. The soaring construction costs and tight state budgets made this method of solving space shortages unacceptable. For example, when CSUN's Oviatt Library was built in 1973, construction costs were \$28.75 per gross square foot. To construct a similar building in 1985, the time of the AS/RS decision, meant an increase of 241 percent in construction costs. The library on average acquired 30,000 books per year which required 3,000 or more square feet of space per year. CSU considered various alternative solutions to the library space problem. The following possibilities were suggested:

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<sup>1</sup> This includes the vendor maintenance contract, which includes site visits 3 times yr. to "oil the machines," verify tolerances, replace parts. Plus, an additional \$ 10k per year for parts and emergency service .

- \* On-campus compact storage
- \* Off-campus storage
- \* Placing more materials on microform
- \* Electronic publishing and laser discs
- \* Automated Storage/Retrieval System (AS/RS) in a library structure.<sup>iii</sup>

The concept of library AS/RS came from the warehousing industry, where it had been used by business enterprises for years. On a small scale, the traditional vending machine is the most common and familiar AS/RS system. When Eaton-Kenway (bought by Harnischfeger (HK) in 1995, and subsequently by Dematic in 2010) first entered the library market in 1989, it had been supplying AS/RSs to businesses for years; Dematic's clients included sportswear maker Adidas in the UK and Liberty Hardware in the United States. It is the only company providing these systems, however, that is well-established in libraries.<sup>iv</sup> At that time, though, being the first library with AS/RS meant that CSUN had no other libraries to look to.

The construction of the AS/RS at the Oviatt was part of the Library-wide expansion, which encompassed the addition of east and west wings. The incorporation of the storage system into the library operations was part of the east wing expansion. However, prior to installing the AS/RS rack in the newly built east wing, building inspectors determined that the AS/RS' structure did not comply with California seismic requirements. Further improvements demanded an addition of the extra floor slab and bolting the ASRS rack to the ceiling. While the necessary changes were inconvenient and delayed the opening, the 1994 Northridge Earthquake proved their worth (fig. 1). AS/RS was the safest place in the Library, and probably the entire Los Angeles area to be. Although the quake devastated the library building and collection (fig. 2), not a single book in AS/RS was damaged.



Figure 1 Exterior damage sustained by the Oviatt Library during the Northridge earthquake in 1994. Oviatt Digital Archives.



Figure 2 Damage to the stacks sustained by the Oviatt Library during the Northridge earthquake in 1994. Oviatt Digital Archives.

Currently the storage facility holds over 857,200 volumes, including bins that contain 15,000 linear feet of archival and special collections materials. AS/RS consists of 13,260 steel bins on a rack structure that occupies an 8000 sq. ft. room forty feet high (fig. 3)



Figure 3. AS/RS rack structure.

### **Storage policy**

The initial population of AS/RS was back-engineered from the goal of freeing 50% of the library stacks capacity, i.e. designating about 500,000 volumes for storage. A number of studies in the early 90-s, still holding true today<sup>2</sup>, had shown that 80% of the use of library materials occurs on 20% of the materials a library owns. Thus, by moving lower use materials to AS/RS, the Library could still ensure that more than 80% of the use of the materials occurs

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<sup>2</sup> In 2010 Cornell University Libraries determined that approximately 45% of print monographs in their collection published since 1990 have circulated at least once to date; approximately 55% of these books have never circulated.

[http://staffweb.library.cornell.edu/system/files/CollectionUsageTF\\_ReportFinal11-22-10.pdf](http://staffweb.library.cornell.edu/system/files/CollectionUsageTF_ReportFinal11-22-10.pdf)

on volumes available in the open stacks. Library materials targeted for storage were identified by the following three criteria: last circulation date, publication date and barcode scanning. Last circulation date of five years and more was used to select materials generally available for checkout, publication date was used for periodical, i.e. non-circulating volumes, and barcode scanning for those material types that needed to be selected on an item-by-item basis, such as Reference collection.

By utilizing these clearly defined parameters, the initial load of the AS/RS, i.e. half a million items, was completed in about two months. Concurrently with the policy for selection into AS/RS, the library developed parameters for returning materials in storage into stacks. Naturally, these criteria were based on increase in circulation of stored materials. However, the reality showed that once materials were designated for AS/RS, they were destined to stay there. This could be explained by the very fact that those were low demand materials in the first place, that serendipitous physical browsing discovery was eliminated, and/or the growing open stacks collection left literally and figuratively no room for materials to return. Plus, the Library's busy life and continued forward momentum left little time for re-evaluating the past.

### **Storage arrangement**

There are two types of storage arrangement in AS/RS: random and permanent. When an item held in *random* storage is taken out of the AS/RS to be used, it gets returned to a different (random) bin. While a requested item is retrieved, another returned item is input into its place. The majority of materials held in random storage belong to the main circulating collection. Conversely, non-circulating materials such as bound periodicals and Special Collections & Archives are held in permanent storage, with assigned location. For obvious reasons, it is optimal to keep multi-volume runs of periodicals together, mainly because the bibliographic records as a rule do not reflect the contents of each separate volume, and thus a single AS/RS request retrieves multiple volumes of one title. Special Collections & Archives materials usually have non-standard sizes and are harder to arrange within the bin and fit into an opening in another bin.

In addition, similarly to periodicals, Special Collections & Archives materials should be kept in a certain order. Therefore, the *permanent* storage items will always return to the same bin. The assignment of the storage type is recorded in the *AS/RS Manager* system, which has a dedicated *Storage Type* field (fig. 4).

There are five sizes of bins available - 6", 10", 12", 15" and 18"- and materials are stored in the appropriate size bin; the average load capacity of a bin is 350 lbs with the maximum load of 450 lbs (fig. 5).

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(INV) DISPLAY LCS INVENTORY INFORMATION - Process by Item Bar Code

Item Bar Code. . . . : 30700003942751
Call Number. . . . . : QA76 .B45
Author . . . . . : BERNSTEIN, JEREMY
Title. . . . . : THE ANALYTICAL ENGINE: COMPUTERS, P
Format Code. . . . . : BOOK
Statistical Category:

Location . . . . . : 01200618
Sector . . . . . : 3C
Configuration Size . . : 10
Storage Type . . . . . : RANDOM
Status . . . . . : AVAILABLE
Access Count . . . . . : 8
Bin Type . . . . . : REGULAR
```

Figure 4. Record in AS/RS Manager system with assigned storage type.

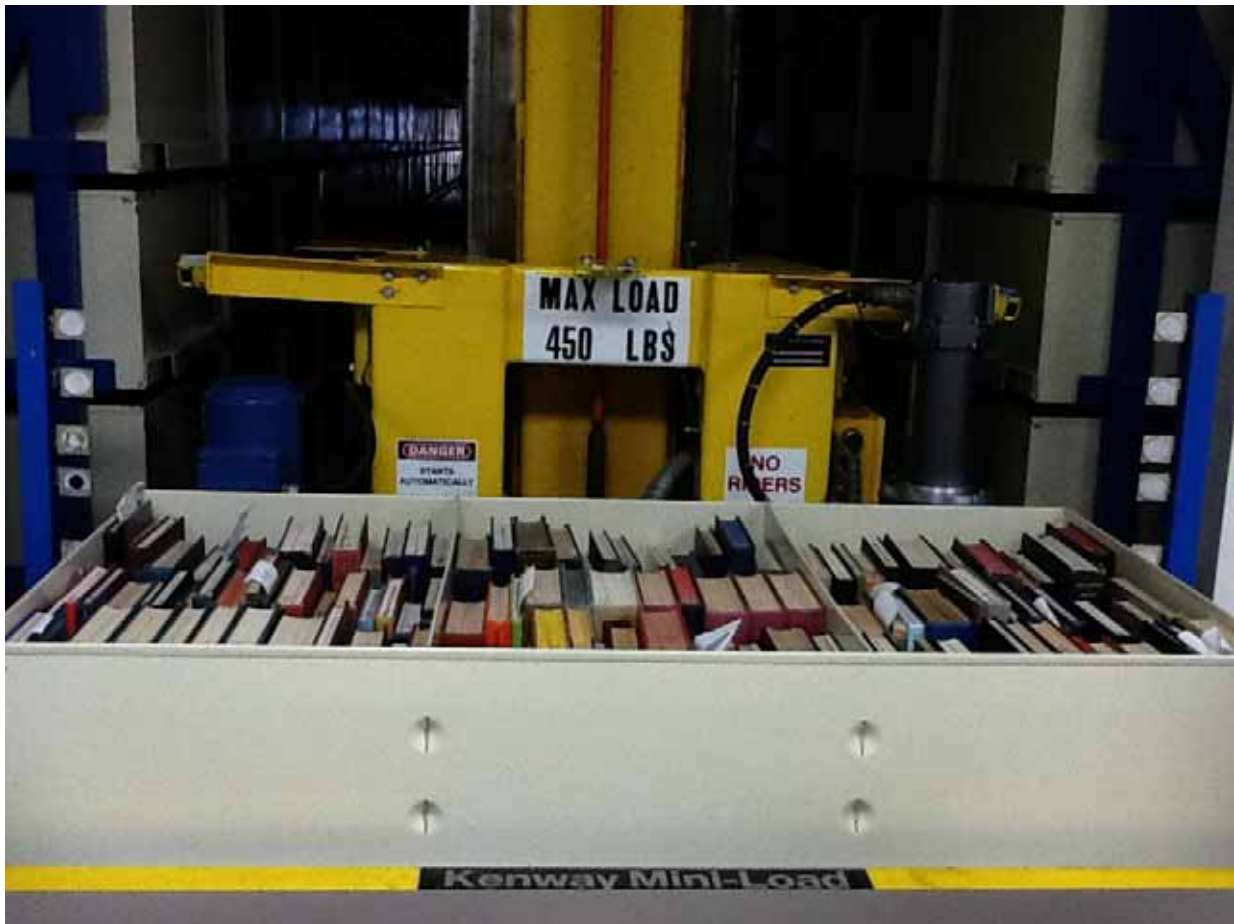


Figure 5. Retrieved AS/RS bin.

Currently the system handles over 15,000 requests per year and the entire process is predicated on the compatibility and synchronous maintenance of the two parallel systems - the Library Catalog (Innovative Inc.) and AS/RS software. Only selected Technical Services and Circulation staff have special authorization to enter data into both systems.

The ability to interact with AS/RS Manager dictated the choice of the Integrated Library System (ILS) at the Oviatt. The Library's first ILS was purchased at the same time as the AS/RS. Bidders for each system -- AS/RS and ILS -- had to agree to work with the successful bidder for the "other" system. GEAC was the chosen ILS. One of the authors of this paper and at the time GEAC employee, Eric Willis, was in charge of developing the bridge between the two systems. The first generation of GEAC was replaced with second, GEAC Advance. However, when it was time to replace Advance, the Library decided to go out to bid, and one of the mandatory requirements was that the vendor had an existing interface with an AS/RS in production. There were only two viable options on the market at that time, and the winner was Innovative Interfaces.

## Operation

When the patron finds a title in the online catalog that is stored in AS/RS, the record displays the location as *Stored*. By clicking the *Request* button displayed within the item record, the patron, after logging in, launches the command for the robotic crane (fig. 6)

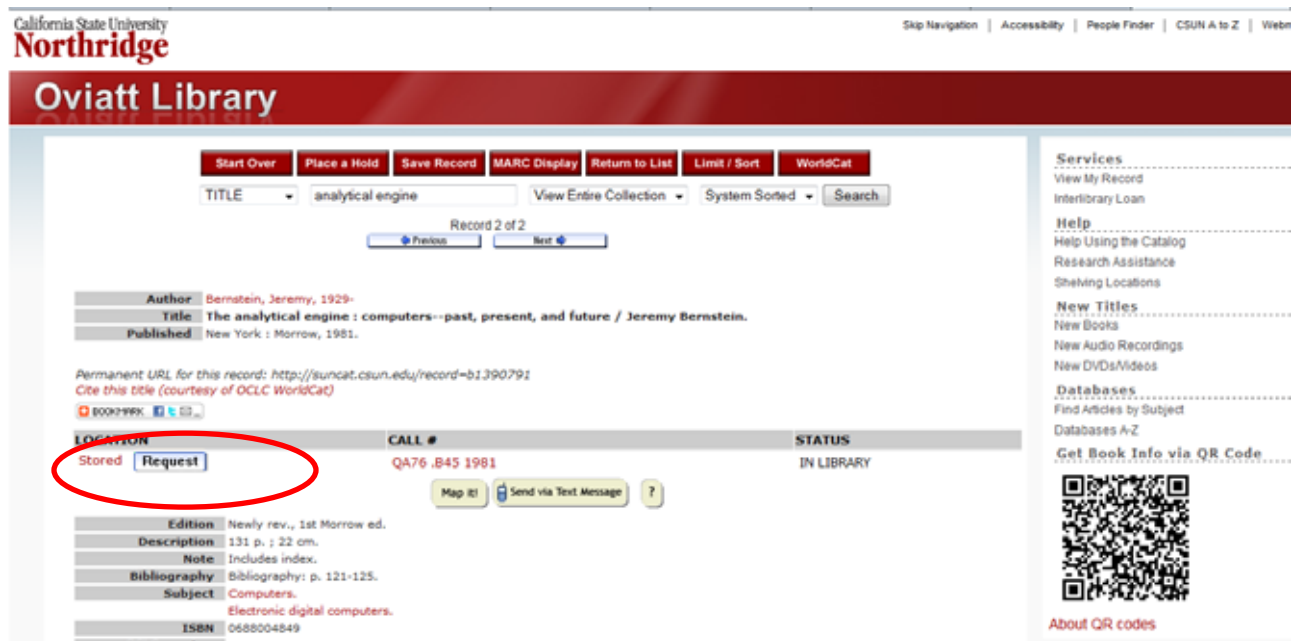


Figure 6 The *Stored* location and *Request* button displayed in the online catalog

The robot detects the command because the library online catalog interfaces with the AS/RS Manager System and retrieves the item. The retrieval of materials from AS/RS is barcode-driven. Each item (book, periodical, box, etc.) designated for AS/RS in Millennium ILS has its location marked as AS/RS Stored (fig. 7).



<b>b11348045</b>					
<b>AUTHOR</b>	Bernstein, Jeremy, 1929-				
<b>TITLE</b>	The analytical engine: computers, past, present, and future.				
<b>PUB INFO</b>	New York, Random House [1964]				
<b>BIBCALL</b>	QA76 .B45				
<b>LOCATIONS</b>	bol				
<div style="display: flex; justify-content: space-between; border: 1px solid black; padding: 2px;"> <span>Summary</span> <span>Record i11685190</span> <span>0 Item-Level Holds</span> <span>0 Bib-Level Holds</span> </div>					
<b>i11685190</b> Last Updated: 12-29-2004    Created: 11-05-2002    Revisions: 19					
<b>COPY #</b>	1	<b>LCHKIN</b>	12-31-1969	<b>LOUTDATE</b>	01-04-1990 :
<b>ICODE1</b>	0	<b>INVDA</b>	0	<b>LOCATION</b>	asrs Stored
<b>ICODE2</b>	-	<b>IN LOC</b>	0	<b>LOANRULE</b>	0
<b>I TYPE</b>	1 BOOK	<b># RENEWALS</b>	0	<b>STATUS</b>	- IN LIBRARY
<b>PRICE</b>	\$0.00	<b># OVERDUE</b>	0	<b>INTL USE</b>	0
<b>OUT DATE</b>	- - :	<b>ODUE DATE</b>	- -	<b>COPY USE</b>	0
<b>OUT LOC</b>	0	<b>IUSE3</b>	0	<b>IMESSAGE</b>	- NO MESSAGE
<b>DUE DATE</b>	- - :	<b>RECAL DATE</b>	- -	<b>OPACMSG</b>	- ---
<b>PATRON#</b>	0	<b>TOT CHKOUT</b>	7	<b>YTDCIRC</b>	0
<b>LPATRON</b>	0	<b>TOT RENEW</b>	0	<b>LYRCIRC</b>	0

Figure 7. Staff view of an item record marked for AS/RS.

When the command is communication to the crane, the barcode, call number, title and other fields from the bibliographic and item record in the ILS are transferred to the AS/RS Manager System. The AS/RS system maps the item barcode to the specific bin location when the item is physically stored (fig. 8)

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(OIR)  OUTSTANDING ITEM REQUESTS DISPLAY
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Item Bar Code	Location	Patron Code	Patron Name	Pickup	Status	Type
30700003942751	01-2-006-18	20700111111111	IFLA	f2	NEW	REGULAR
AUDIT-01102107	01-1-021-07				NEW	AUDIT
AUDIT-01102207	01-1-022-07				NEW	AUDIT
AUDIT-01102307	01-1-023-07				NEW	AUDIT
AUDIT-01102407	01-1-024-07				NEW	AUDIT
AUDIT-01102507	01-1-025-07				NEW	AUDIT
AUDIT-01102607	01-1-026-07				NEW	AUDIT
AUDIT-01102707	01-1-027-07				NEW	AUDIT
AUDIT-01102807	01-1-028-07				NEW	AUDIT
AUDIT-01102907	01-1-029-07				NEW	AUDIT
AUDIT-01103007	01-1-030-07				NEW	AUDIT
AUDIT-01103107	01-1-031-07				NEW	AUDIT
AUDIT-01103207	01-1-032-07				NEW	AUDIT
AUDIT-01103307	01-1-033-07				NEW	AUDIT
AUDIT-01100108	01-1-001-08				NEW	AUDIT
AUDIT-01100208	01-1-002-08				NEW	AUDIT

Figure 8. Request display in AS/RS Manager system.

As requests are filled, a slip containing information such as the patron name and identification, the bar code, and a brief bibliographic entry is generated. The slip is inserted into the book and it is ready for a patron's pick up.

The last two digits of the bar code of each book are written on the top edge when it is stored, allowing the AS/RS operator to find the book easily. The operator reads the bar code in the book with a scanner, to confirm that it has been picked up and delivers it to the circulation desk. Once a request is received by AS/RS Manager system, it takes 15 minutes for the materials to be ready for the patron's pick-up.

### **Renovation**

Although the AS/RS has proven itself to be very reliable, there were certain aspects of the original system design that after 20 years were either no longer maintainable, or had been replaced with even more reliable components and design. Recently, almost 20 years later the CSUN AS/RS underwent a major renovation of hardware. The upgrade to the physical plant took more than three months to complete and had a minimal impact on library services. The work was phased in gradually, which enabled most of the system to remain functional. Usually only one aisle was down at any given time. Since it was impossible for the Library catalog to know which titles are stored in which aisles, and thus unavailable, a generic message was posted on the catalog's AS/RS request page: *Some titles may be unavailable for retrieval*. Although there were possibly some upset patrons, the library did not hear any complaints.

The original "controls" onboard each crane utilized Intel microprocessor boards dating back to the 1980's. Current technology uses "programmable logic controllers." The positioning system that was responsible for ensuring the crane deposits each bin in exactly the right place utilized a system of rollers and counted "ticks." Current systems use laser technology for positioning.

### **Future directions**

In recent years there has been a shift in the role of library on a university campus. The increased usage of laptops, tablets and mobile technology in student learning, as well as changes in curriculum towards student-created multimedia content and group assignments, transformed expectations for the library from a repository of print collections to technology commons, group study space and media lab. Many universities integrate libraries into student learning by adding new facets to the services, such as learning resource centers, writing centers, and even cafés.

Under the pressure of new demands, the physical space is at a premium and print materials yield to space expansion. A wave of library redesigns is sweeping the country. The Oviatt Library is getting ready for a renovation of its own.

Much like in the late eighties, AS/RS acts as an economical solution for the space problem. While an estimated annual cost of storage and maintenance per volume in open stacks is \$4.26, the same materials stored in AS/RS cost \$0.86.<sup>v</sup>

Although holding materials in closed storage has its disadvantages, such as the loss of shelf browsing and serendipitous discovery, it allows the libraries to continue acquiring materials unavailable or unaffordable in electronic format, and forces continual analysis of circulation statistics in order to keep just-in-time materials just on hand.

## References

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<sup>i</sup>California State University, Northridge Website. <http://www.csun.edu/aboutCSUN/>. 19 June 2012.

<sup>ii</sup> "Library History and Facts." Oviatt Library Website. <http://library.csun.edu/About/HistoryandFacts.> 19 June 2012

<sup>iii</sup> Tanis, Norman E., and Cindy Ventuleth. "Making Space: Automated Storage And Retrieval." *Wilson Library Bulletin* 61.(1987): 25-27. *Library Literature & Information Science Full Text (H.W. Wilson)*. Web. 11 June 2012.

<sup>iv</sup> Rapp, David. "Robot Visions." *Library Journal* (1976) 136.15 (2011): 20-24. *Library Literature & Information Science Full Text (H.W. Wilson)*. Web. 10 June 2012.

<sup>v</sup> Sustainable Collection Services. <http://sustainablecollections.com/the-case-for-deselection/>. 19 June 2012