A UK first: an automated, high-density storage solution for the British Library

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This paper will give a brief overview of the new storage building being planned by the British Library (BL) at Boston Spa in Yorkshire. I shall outline the BL's property strategy to 2020, and the objectives for the new storage facility. I will then summarise our investigations into various storage solutions, focusing on high-density storage and fully automated systems. This will be followed by a review of the fire protection systems, chosen with the emphasis on low-oxygen environments. I will then talk about the key issues currently being addressed, the next steps and what we hope to deliver.

Property Strategy

The BL's property strategy is to concentrate all operations on our two freehold sites at St Pancras, London and Boston Spa, Yorkshire.

- At St Pancras, we will store high-use, high-value and fragile collection material.
- At Boston Spa, we will store high-use collection material primarily for loan, for document supply services, and low-use collection material which we are committed to retain in perpetuity.

From a storage perspective, the key driver is that we will be full by 2006/7. We anticipate that our collections will continue to grow at a rate of 12 linear km a year. In addition only 42% of our current collections are housed in appropriate conditions and this is something we want to change. In 2002 we bid successfully to the Department of Culture, Media and Sport for funding for a new storage facility which will provide 150 linear km of new storage space. We were awarded a capital sum of £11 million.

Objectives

The key objectives for the new storage facility are:

- To provide a minimum of five years growth space from 2006/7.
- To facilitate the vacation of the BL store in Woolwich - a very poor leasehold building in south London.

The quality of the new storage should meet British Standard 5454:2000.[i] This will increase the proportion of the collections housed to this standard from 42% to 48% by the time we have completed the initial moves in 2008. Obviously the ratio will rise as we continue to fill the building. The new building will house low-use collections which we are committed to retain; mainly serials, but also books, some multimedia items such as CDs and DVDs and some archives and records as well, which means we will fall within the remit for National Archives inspection of this storage space.[ii] We will maintain service standards to our users and in some areas there will be improvements. We aim to deliver a building that lasts for seventy years, that is sustainable in terms of running and life cycle costs and that meets UK Government directives on green issues**.** Finally, we aim to deliver additional storage for best value for money.

Storage solutions

We carried out investigations into different types of storage solutions. First we considered established conventional storage facilities. We looked at different combinations of low and high racking, fixed and mobile racking. None could provide the quantity and quality of storage that we required for the funds available.

High-density storage

Last summer we turned our attention to the high-density stores which are becoming increasingly commonplace in research libraries in the USA. Listed below are common features of such storage facilities:

- Racking is up to 12m high.
- Documents are stored within containers, usually in archival boxes.
- Boxes are stored two-deep.
- All items are individually sized and barcoded.
- The stores are used to house low-use material.
- There is a manual system of retrieval, using forklift trucks.
- They use warehouse management system software.

There are over seventy such facilities in the USA, mainly in research libraries, most based on the high-density store at Harvard University. All of these stores have proven track records, and many are co-operative stores renting space and services to other libraries. The stores are relatively easy to build; they are built in modular fashion, new modules being built as and when there is the demand and funds become available. It is straightforward to create separate compartments for collections requiring different environmental conditions and levels of security. We thought that high-density storage was a very exciting possibility. It could save up to 40% of the footprint of the building compared to a conventional store, maximising space and saving building costs. However, it would be a challenge, not least because few of the Library's existing collections are barcoded and high-density stores rely on this as their key method for storage and retrieval. We undertook a study to assess the cost of retrospectively barcoding over 3 million items, and you will not be surprised to learn that we decided that we simply did not have the time or the resources to do this. However, we did feel that we could use the warehouse management system software to work with our existing shelfmarking systems. We made the decision to go for a high-density solution.

Automated systems of storage and retrieval

In the Harvard University high-density store boxes are picked and replaced manually by a forklift truck driver. Semi-automated systems are similar, but the operator rides within a crane which runs on low and high level rails. This means a greater height can be achieved, something like 20m. We decided to look at fully automated systems of storage and retrieval. We wanted to investigate best practice in the commercial warehousing sector, as well as in libraries and archives.

In a fully automated storage and retrieval system a container of books is retrieved by a combination of cranes and conveyors. The container is moved on to a picking station where staff can retrieve individual items from the container. The automated cranes run down aisles between the racking. The system relies on software for all aspects of the operation. Staff do not have to go to the shelves, so it is possible to have

racking to much greater heights; 30m is not uncommon. Staff work in physically separated office environments – the picking areas. An automation integrator provides the whole package of racking, containers, cranes, conveyors, picking stations and software; basically the insides of the building. We visited two repositories that use fully automated systems, the Turin State Archive in Italy (Fig 1) and the National Library of Norway (Fig 2). The storage building at the National Library of Norway is 60m long, has racking that is 14m high, and has a capacity of about 50 km. If we were going to opt for a building like this we would need something three times the size. The National Library in Japan and the Mormon Record Center in Utah also use fully automated storage and retrieval systems.

Fig. 1
Fully automated storage facility at the Turin State Archive

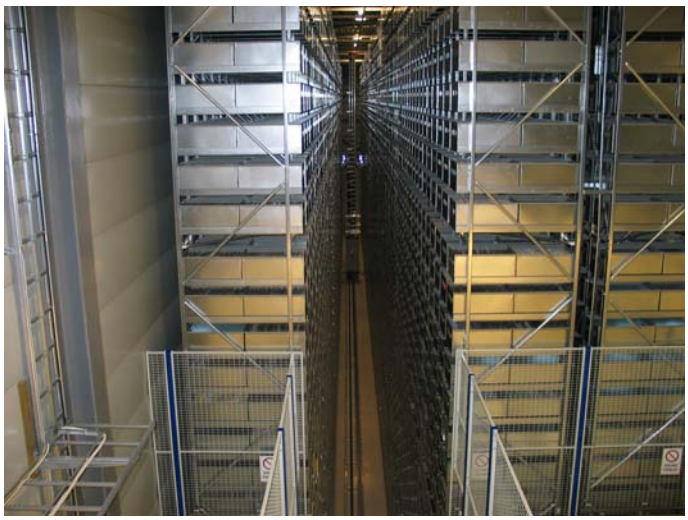

Fig. 2
Fully automated storage facility at the National Library of Norway

Worldwide there are fifteen libraries using fully automated systems. It is obviously still not commonplace, but the list is growing. It is the most affordable of the high-density options because it maximises the footprint of the building. We are planning a storage building that is 81m long, 22m wide, with racking 20m high. It would easily cope with our anticipated usage levels of 170,000 requests a year when the building is full. That is low use, but there is a huge amount of material. It reduces the anticipated staffing level from nineteen for a conventional store to eight or nine. Due to the physical separation of staff from store there are no health and safety concerns about operating forklift trucks and cranes. It means that we can have a dark store with only

emergency lighting, and it gives us the opportunity to introduce innovative fire prevention systems. The decision to go for full automation has been approved, and we have appointed FKI Logistex to carry out the design stage.

Fire detection, prevention and suppression systems

For fire detection an early decision was made to go for an aspirated system (VESDA-Very Early Smoke Detection Apparatus). This is the system most commonly used in high stores.

As for fire suppression systems sprinklers are commonly used in high-density stores in the US. However, we had concerns about water and smoke damage in the event of a fire and the effectiveness of sprinklers in such a huge high-density store containing library materials. We had similar concerns about high-pressure misting systems which in addition seemed incredibly expensive. So we decided to look more closely at fire prevention systems, and particularly the use of low-oxygen environments.

A low-oxygen environment system operates at 15% oxygen. It works on the principle that because ignition cannot take place the material should not be damaged. The usual mixture of gases we breathe contains 21–22% oxygen. However, we can breathe in environments containing 15% oxygen. Do not forget that usually there is no one in the storage area; people should only be there for maintenance purposes. As a bonus, sensors used to monitor the oxygen concentration can be used for smoke detection. The big challenge is to make the storage area airtight. Low-oxygen environments are used in the nuclear and defence industry, and in the retail sector. We visited a small archive in Holland, and the Hugo Boss factory in Stuttgart, Germany both of which use low-oxygen environments. The upfront and running costs are very similar to sprinkler systems. We undertook a full risk assessment of low-oxygen environments and only recently decided to go for this option. However, we will continue our investigations, make further visits, and work on life cycle implications and cost, in particular the impact on the longevity of the collections. Following discussions with our designers and the local fire authorities, we decided not to go for compartmentalisation**.**

Temperature and Relative Humidity

We are going for the lower end of the British Standard in terms of environmental parameters, that is 13–16˚C (55–60˚F) with a target of 14˚C (57˚F), and relative humidity between 45% and 60% with a target of 50%. We are not opting for multiple environmental specifications in this particular building.

Salvage Planning

The key issue here is how we get access to material if there is a problem and the cranes are out of action. A consultancy is underway looking at ways of mitigating the risks to the collections. A low-oxygen environment is the key factor here. In the event of system failure, there is a window of 90 hours before oxygen levels rise above the 15.4% which is needed to allow combustion. We are looking at the reliability of electrical equipment, a robust maintenance programme and constant monitoring of oxygen levels**.** For business continuity, we are planning back-up systems, both for the building and automation systems**.**

Containers

We spent a lot of time defining the optimum size of containers which will be designed to keep stock in our existing shelfmark sequences. A fully loaded container will weigh up to 103 kg and will be about a metre in length. We have carried out risk assessments on the rigidity, robustness and performance in a fire of metal and plastic (both polypropylene and polyethylene) containers. We have decided to go for plastic containers, probably polypropylene, as this material meets all of our requirements, and is considerably cheaper than metal. There is also the added advantage that this material is recyclable. We are now working with the Integrator on a detailed container design.

Software

Together with the Integrator we are looking at specifications for the speed of acceleration and deceleration of the cranes in order to minimise movement and therefore damage to items as they travel throughout the store. We are also developing specifications to link the British Library's IT systems, its catalogues and circulation systems with the new warehouse management system software, as this is crucial to how we will operate the building. For collection management operations, the warehouse software will optimise container location, eventually storing very low-use stock at the furthest part of the store. We are also considering using the flexibility of the software to store the most valuable material at the bottom of each aisle to assist salvage planning. We are also considering using bar codes or RFIDs for new stock being placed in the building.

Next Steps

The architect's integrated design specification is due this month. We go to Leeds planning committee in December 2004.[iii] We are about to embark on a major programme of preservation preparatory work on collections scheduled to be moved. We have initiated a book cleaning programme (which utilises book cleaning machines), a boxing programme, using ready-made and made-to-measure boxes (we have bought a box-making machine for this purpose) and a shelf maintenance programme, in order to ensure that all items are in the correct sequence.

In terms of collection moves, the overall strategy and logistics will be very different from conventional moves. Instead of items being taken off the shelves and put into crates, we plan to use the actual containers in which the material will be stored in the new building to move the stock. This will mean that the material will be handled only once during the move.

In terms of service developments we will develop on-site scanning facilities for articles, although we know that the majority of our users, particularly of serials, will continue to request the physical items. We expect that there will be an increase in the volume of material transported daily between Yorkshire and London. The effect of transportation on the collections will be monitored.

What will we deliver?

I would like to emphasise here that this is very much a project in progress. Although we have made many of the key decisions, some issues are still being researched and investigated further. We are planning to deliver a sustainable building ready for occupation in October 2006, which will provide 150 linear km of storage space that

meets British Standard 5454: 2000. It will be a dark store except for emergency lighting. There will be a separate office environment in the picking stations which will be run by a team of eight or nine staff when the building is full. The service to our users will be at least as good as if not better than the existing service. In November 2004 we will learn the outcome of our second bid to the Department of Culture, Media and Sport (DCMS) for funding for a second 150 linear km building. If the bid is successful this building would be operational in October 2008.[iv]

Conclusions

Care of the collections lies at the heart of this project. We are still learning from other libraries, archives and the commercial warehousing sector. This type of building will undoubtedly have an impact on any future revisions of British Standard 5454. The Library is going for a vast high-density store that is fully automated, and is pioneering the use of a low-oxygen environment. It is a radical step for the Library. It represents a huge change of direction in the way we manage our collections.

Notes

[i] *BS 5454: 2000 Recommendations for the storage and exhibition of archival documents*, British Standards Institution, 2000.

[iiii] *The National Archives Standard for record repositories*, The National Archives, 2004. http://www.nationalarchives.gov.uk/archives/framework/pdf/standard2004.pdf

[iii] The British Library was granted planning permission in principle in February 2005, with full award anticipated May 2007.

[iv] DCMS has awarded the Library part of the capital funding for this second building.