RFID Implementations in California Libraries:

Costs and Benefits

Elena Engel

July, 2006

This study was supported by the U.S. Institute of Museum and Library Services, under the provisions of the Library Services and Technology Act, administered in California by the State Librarian.

Principal investigator: Elena Engel

Consultant: Karen Coyle

RFID Implementations in California Libraries:

Costs and Benefits

Elena Engel

Executive summary

Purpose

The purpose of this study is to investigate the extent of implementation of RFID systems in California public and academic libraries, and to ascertain the goals of libraries in implementing RFID, as well as the costs and benefits associated with the use of this technology. The gathering of such information, it is hoped, will inform and assist libraries that are contemplating the purchase of RFID systems by providing them with information from libraries that have already adopted such systems. This data can provide a framework, a planning tool, for libraries to use in making their own cost-benefit projections and can help inform their decisions about RFID adoption.

Method

Two surveys were done. In the first, a list of libraries that have either initiated or completed the process of implementation was compiled. These libraries were sent surveys requesting information about their library, choice of vendor, date of implementation and the cost of equipment, tags and supplies. The purpose of the second survey was to obtain more detailed information from these libraries about the process of implementation, the costs associated with it, the goals of implementation, the on-going costs, the benefits, detriments and cost savings derived from the use of RFID systems.

Surveys

Twenty-seven California libraries were known to have purchased RFID systems by the data collection date (end of 2005) of the first survey. Twenty-four of these libraries responded to the first survey. Of that number, two-thirds (16) were public libraries and one-third (8) were academic libraries. Collection size being tagged ranged from 3,500 items to over half a million. The earliest date of implementation was 1999, with seven libraries (29%) implementing between 1999 and 2002. The rest of the libraries were implementing between 2004 and 2006, with 11 libraries still in the process of implementation during the second data collection period (Jan-May 2006). Seventeen of the libraries (71%) purchased RFID in preparation for a move into a new or renovated facility.

The second survey requested more in-depth information about the goals, process and results of implementation. Eighteen libraries responded. The most frequently cited major goals, reported by 13 of 18 libraries (72%), were to promote patron self-check out and to increase security/reduce theft. Of the 18 libraries that responded to the second survey, however, only 9 (50%) of the libraries were either complete or far enough along in their implementation to provide information about on-going costs, benefits and detriments. The most frequently reported major benefits (5 of 9 libraries or 56%) were patron self-check and patron satisfaction (5 of 10 responses or 50%).

Study limitations

This study should be regarded as preliminary. It can provide a jumping off point for future studies once more data becomes available. The number of California libraries known to have purchased RFID systems is very small – only 27 libraries. Even less information – from nine reporting libraries – was gathered about systems that have been implemented to the degree that

most or all of the system is up and running. Because of the limited number of libraries able to provide details about the results realized from RFID, general conclusions cannot be drawn. Further, because most of the implemented systems have been in operation only a short time, many of the benefits and detriments have not yet become entirely clear. In these areas, the information presented should be regarded as anecdotal, or at most, somewhat indicative. The value of this study, it is hoped, is to inform libraries that are trying to learn more about the costs and benefits of RFID by reporting on the experiences of libraries that already have such systems, even though these reports lack statistical weight.

Goals

The two most common goals in migrating to RFID, cited by 13 of 18 libraries (72%), were to introduce or increase patron self-check and to insure the security of materials. Typically, public libraries, with their larger circulation, were more interested in self-check, while academic libraries were more interested in security. The ability to do inventory interested each of the 18 libraries that responded, with 11 of them (61%) seeing it as a primary goal, and seven of them (39%) listing it as a secondary goal. Libraries were also asked what they did not hold as a goal. Reduction in the cost of processing new materials was not expected to be realized ("not a goal") by 11 of the libraries (61%). 9 libraries (50%) were not seeking to implement patron self-return (patron self-check in of materials).

Benefits/Detriments

The two most common benefits realized by libraries that implemented RFID were patron self check and patron satisfaction. Of the nine libraries that reported on benefits realized in this category, five libraries (56%) said that patron self check was a major benefit, and three libraries (33%) reported it as a minor benefit, for a total of 89% indicating it as a benefit. Patron satisfaction was reported as a major benefit by five libraries out of 10 responses (50%), as a minor benefit by two libraries (20%), thus totaling 70%. Reduction in lines at the circulation desk were reported as major benefits by four libraries (40%), and as minor benefits by another two (20%). Increased equipment reliability was realized by four libraries out of seven responding (57%) as a major benefit, and by one library as a minor benefit. Four responses were received about detriments pursuant to implementation. Two libraries (22%) were unable to realize reductions in the cost of processing new materials. One library each reported that processing materials was not faster, and that security was not increased/theft was not decreased after adoption of RFID.

Costs and benefits

Not surprisingly, a large cost associated with adoption of RFID is the expense of the individual tags. The average cost of tags reported by libraries is $.68 (at time of initial purchase). AV tags tend to be more expensive, at $1.08 each. New equipment also is costly, but comparable to the electro-magnetic systems currently in use in many libraries. Tagging is very labor intensive, with the average time to tag clocked at one minute per item. Depending upon who does the tagging, this can also be a significant expense. The cost of purchasing tags for new materials after implementation seems comparable to the cost at the time of original purchase. Maintenance costs vary since they generally are based upon the value of the equipment purchased.

Benefits in the form of cost savings were realized both in the reduction in number of staff needed to circulate books and in improved productivity of staff. Of the nine libraries that

reported on benefits, only four provided information on circulation staff levels before and after implementation. All four libraries were able to reduce the number of circulation staff assigned per hour. At two of these libraries, (both of whom moved into new buildings), circulation also increased. So either less staff were circulating the same amount of materials, which provides cost savings, or less staff were circulating more materials, indicating both cost savings and increased productivity. Staff check in with RFID also looks like a promising area to find cost savings and/or increased productivity.

For libraries without previous security systems, the installation of RFID security gates should certainly cut down on theft, which would represent a significant savings. However, we have no data from any of the respondents which quantifies the amount saved in materials not stolen. For libraries that already owned theft detection systems, the situation is even less clear. We have no data about whether the RFID detection rate is better than previous systems, and no loss-rate data to compare.

Inventory systems also seem a very promising way for libraries to improve service and potentially save money when misshelved, missing and requested items are found. However, not enough libraries have implemented this system yet for there to be much data.

Other benefits reported by libraries relate less to cost and more to improvements in quality of service, including patron satisfaction (5 libraries), reduced lines at the circulation desk, and increased equipment reliability (4 libraries).

How to figure costs and benefits

Based upon the information gathered from the libraries in this survey, an outline and a spreadsheet have been included in this report that list the categories of possible costs and benefits to be considered when planning for an RFID adoption. Again, it should be emphasized that these categories were generated based upon a very limited number of responses, and can only give an indication of where cost and benefit may be realized. Each library will have to look at its own situation and goals, and attempt to project these figures based in part upon the experience of other libraries and on its unique configuration of factors.

Conclusion

The old saw that "more research is necessary" is apt in the case of RFID in libraries. Although this report hoped to provide more specific guidance through the collected experience of libraries that have already adopted the technology, this goal proved illusive due to the small number of libraries that are fully implemented, and the short amount of time since implementation. It will be helpful, not only for each individual library deciding to purchase an RFID system, but also for other libraries if certain baseline data are collected that can form the basis of a "before and after" snapshot. Thus, future studies could have comparative data on goals realized or not, as well as benefits and drawbacks of RFID systems. Such a study could give a more definitive answer about whether the benefits outweigh the costs of RFID systems. But, even with such data, value must be determined according to goals set, and should be considered, to the best of each library's ability by thoughtful planning before purchase.

Introduction

Libraries, like other enterprises, are interested in saving time, money and labor. In private business, these objectives are primary because they serve the bottom line. Public entities such as libraries, however, often place excellent public service as their first priority, while still looking to save money and time. Shrinking budgets may dictate that fewer resources will be available for providing the same amount of service. Libraries, like private businesses, are searching for ways to control costs, but without having to compromise their lifeblood – providing free materials and a full range of superior services to their users.

Currently, technology is most often the hoped-for solution to tightened budgets. When budgets fail to keep pace with use or inflation, less staff is used to do more. Libraries hope that increased use of various technologies can help them to continue to provide the same level of service without increasing staff. Implementation of technology, upgrades and breakthroughs promise better performance, more efficiency, faster service, and less cost. Libraries, as stewards, collectors and aggregators of information, are deeply imbedded in the technology cycle. Changes in technology come so quickly that neither budgets nor staff expertise can keep up. Often with the sense that they are running behind the newest advances, libraries rarely have time to thoroughly evaluate before they implement. In fact, evaluation may seem superfluous, because by the time libraries are able to implement, the value has already been proved elsewhere. In the case of Radio Frequency Identification (RFID), however, libraries are early-adopters of a still-emerging technology. With only a few libraries utilizing RFID and those only for a short time, libraries are left with little evidence to determine the value of RFID to them.

Radio Frequency Identification, although initially costly to implement, promises, according to its supporters, to provide savings in time, money and labor without diminishing the level of core services provided. This study seeks to provide a method to help libraries evaluate whether the probable costs and benefits of RFID make sense in their unique situation. It will look at the state of implementation of RFID in California libraries and use the data gathered from those libraries as suggestions and indications of what costs and benefits other libraries might expect. Since each library is different, with different goals, variations in size, collections, staff, labor costs, open hours and ways of providing service, there cannot be one single formula for determining what costs and benefits could be obtained that is applicable to every library. This study aims to provide a general evaluative method, pointing out which of a variety of factors need to be considered in determining the value of the technology to the institution.

RFID in Libraries

State of the Art and the Market

RFID technology is being implemented in a number of industries. Supply chain implementation is perhaps one of the most frequently mentioned applications of RFID tags and equipment. Manufacturers, warehouses and retailers are using RFID tags on pallets and shipping containers to track goods throughout their travels to store shelves. Giant retailers such as Wal-Mart and grocery stores such as Albertson's have begun to require their large suppliers to tag merchandise destined for their stores. Large farms are using tags to track their livestock, and growers and shippers are tagging produce cases. RFID is being implemented in hospitals, government agencies, museums, prisons, law firms and libraries.

Industry publications discuss the uncertainty felt by many businesses as to the value and benefit of RFID.[1] Businesses are concerned about the still-evolving standards for RFID technology, the cost, and the ability to interface tag technology with existing systems.

The type of application seen in libraries – permanent tagging of items to track their circulation status – is quite recent, dating back only to the late 1990's**.** Singapore Public Library claims to be probably the first application of RFID technology fully deployed in a library environment in 1998.[2] [3] There is as yet little data available to determine the cost effectiveness of RFID applications. Libraries, too, wonder whether the expense is worth the presumed gains in efficiency. They are concerned that the still-evolving technology may leave them with yesterday's product that no longer works with a new generation of equipment. And since the tags used in libraries must always be "live," that is, readable throughout the life of the book, libraries are concerned about privacy, that is the ability of unknown others to read the tag's information without the patron's knowledge or consent. (See bibliography for more on RFID and privacy concerns.)

As of May 2006, the date of the end of data collection for this study, 27 academic and public libraries in California have at least started the process of implementation. Another three libraries were known to have purchased systems, but had not started implementation by the end of data collection, and so are not included in this survey. Since some libraries are part of systems or have multiple branches, there are a total of 38 individual sites either currently implementing or completed. Earliest implementation was by two academic libraries, in 1999, with a public library following in 2000.

Models of Implementation

There are many ways in which RFID can be used in libraries. The models of implementation can vary based on the library's needs. Some libraries have heavy circulation activity and will focus their attention there. Others are interested primarily in the combined circulation and security functions of RFID. Models of implementation for circulation intensive libraries vary from the "Singapore model"[4] in which circulation services, including check out and check in are as self-serve as possible (approaching 98%), to the use of RFID as an adjunct to the traditionally staffed circulation desk. Greater savings, and therefore better return on investment, is most likely to be realized the greater the self-service component. However, libraries may approach the move to patron self-serve quite cautiously, fearing a degradation of service when people-serving-patrons are replaced by machines-serving-patrons. The full capacities of RFID technology may be underutilized by libraries that are seeking to retain quality patron experience. It certainly has not

been tested nor proven that self-service is inferior to staff-mediated check out (and check in) service. The point is that retention of the perceived quality of service may trump promised cost savings.

The RFID Study

Methodology

This study covers California public and academic libraries that have implemented, or are in the process of implementing, RFID systems. In order to compile a complete list of such libraries, the author contacted libraries known to have RFID installations, listservs for RFID users, and vendors of equipment and tags. Contact was then made directly with the libraries to confirm that they were indeed RFID sites.

A brief survey was sent to these libraries via e mail, which covered general information about the library, the type of system purchased, the supplies and equipment selected and their cost. Each library decided who best could answer the survey questions. Responders included a variety of administrative staff including library directors, deans, heads of IT, heads of branches and library managers. Of 27 surveys sent, 24 responses were received. (See Appendix 1 for a list of the responding libraries). Another three libraries are known to have agreed to purchase systems, but at the end date of our data collection, had not yet begun implementation, and so are not included in this survey. The first survey form is included as Appendix 2, Survey 1.

A more in-depth survey was then sent out to the original 24 respondents. Those libraries that had not yet finished implementation were sent an abbreviated survey dealing with their goals in implementing and the conversion process. Libraries with completed installations were sent a longer survey. Eighteen responses were received. Follow-up phone interviews were requested with all respondents, and conducted with 11 libraries in order to discuss and clarify the survey responses. Appendix 2, Survey 2 contains the second set of survey forms.

This second survey listed a number of goals for implementation suggested by the authors and asked libraries whether these goals were primary, secondary or not among their goals. Space was also provided for libraries to suggest other goals not on the list. Information was requested about the process of tagging and the installation of equipment. Those libraries that had completed implementation were asked about the benefits and detriments derived from implementation. Again the authors provided a list of choices and space to fill in other answers. Information about specific changes since implementation was also solicited.

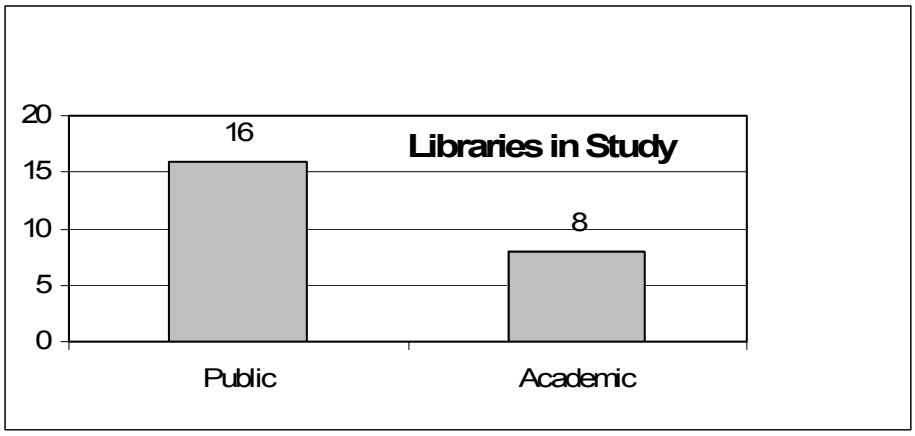
Study limitations

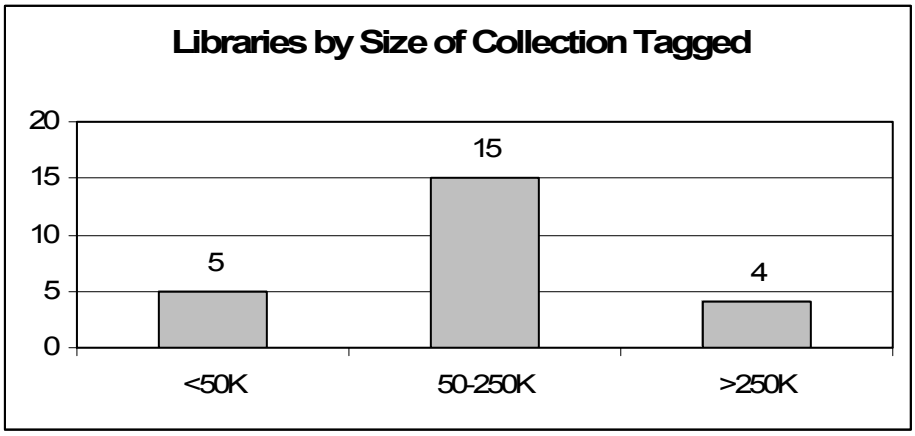
Because of the small data size, the variation in the systems and the way they were implemented, it is difficult to draw conclusions that can be generalized to all libraries. It was decided to capture both quantitative and qualitative results to more adequately capture and convey the results of the survey. Results such as reaching "higher patron satisfaction" or "shorter check-out lines" may not have been quantified by libraries before and after their implementations, and must be treated as "quality improvements." It is hoped that these observations, although perhaps not statistically significant, will provide libraries with tools to make reasoned decisions about RFID systems. The responses collected from libraries can provide indications about costs and benefits that may be possible for other libraries to derive from RFID.

As more libraries adopt RFID systems, the data set will become more widely significant. However, libraries will also need to collect "before and after" data that can help illustrate what magnitude of changes can be expected after implementation. In that way, future studies should be able to draw more general conclusions.

Libraries Included

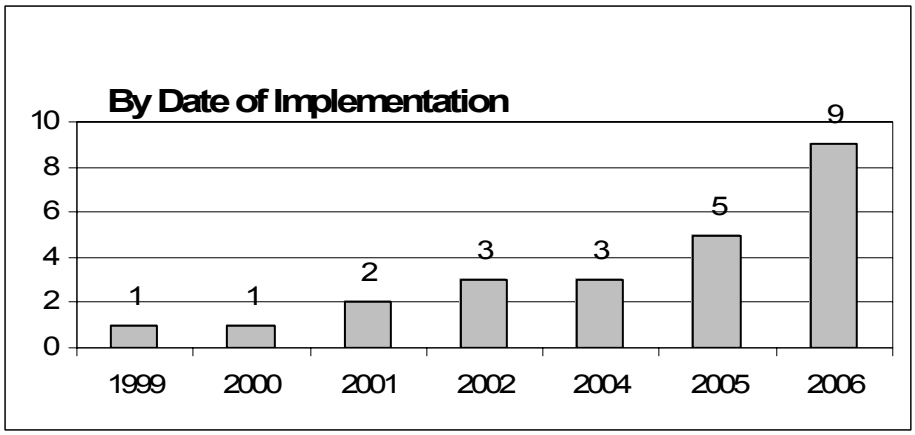
Of the 24 libraries that responded to the initial survey, 16 were public libraries and eight were academic libraries. Five libraries had collections smaller than 50,000; 15 had collections between 50,000 and 250,000 items; and four had collections greater than 250,000.





One of the main functions of RFID tags is to interact with library circulation systems. In looking at the libraries in the study, circulation of materials as a percentage of the overall collection size was markedly higher in the public libraries as compared to the academic libraries, with public libraries circulating many times their collection size each year. This difference in circulation activity helps to explain the difference in goals for RFID implementation, discussed below, between academic and public libraries.

Because RFID is new technology, few libraries have lengthy experience using it. The earliest date of implementation among our surveyed libraries was 1999, as a "proof of concept" installation, on a small portion of the library's collection. Six more libraries installed RFID systems between 2000 and 2002. The remaining 17 libraries, or 71% of our sample, began installation between 2004 and 2006. Eleven of those libraries (46%), at the end point of our data collection in May 2006, had not yet finished implementation, and therefore did not yet know what its affect would be on library operations. We were much better able to gather information about implementation costs than we were about realized benefits partly because few of the libraries in the study had reached the point where actual benefits would be recognized.



These 24 libraries represented 38 sites that had installations of RFID. Many of these libraries are part of large systems with still other branches or sites not yet involved with RFID. They've started with a small number of sites and expect to expand the system to their other branches in the future. Some libraries had chosen to implement RFID first at a smaller branch. These libraries will probably have greater gains (or losses) to report when their primary site or sites implement RFID systems. Two libraries had only implemented on an experimental basis for a limited part of their collection, and did not indicate whether they expected to expand or not.

Libraries were most likely to purchase RFID systems when they were preparing to move into larger new or renovated facilities. Seventeen of the 24 libraries (71%) reported that they were in that situation.

Goals: Why the Libraries Chose RFID

Many of the libraries in our study first purchased RFID at a time of capital improvements, either the construction of a new library building or the renovation of a current one. In cases where the installation of RFID was in a single branch of a library with other facilities, the plan was nearly always to extend RFID to the remaining facilities, both to create compatibility for purposes of materials exchange and to realize the intended benefits of RFID throughout the library's system.

> "With 34 branches in our system, we are selecting branches for future installations for these functions based on circulation, staffing levels, building readiness and theft rate."

Within our sample of libraries, the particulars of their situations varied greatly, however. They ranged from new libraries that would rely heavily on automation to existing libraries that had never had any automated systems, not even an online catalog. What they had in common was a desire to take advantage of the latest technology to increase staff effectiveness so that the library could provide excellent user service.

Surveyed Goals

The participating libraries were asked to indicate their primary and secondary goals for implementing RFID. They were also asked to indicate if there were goals on our list that specifically were not goals for their implementation. The list of goals on our survey was:

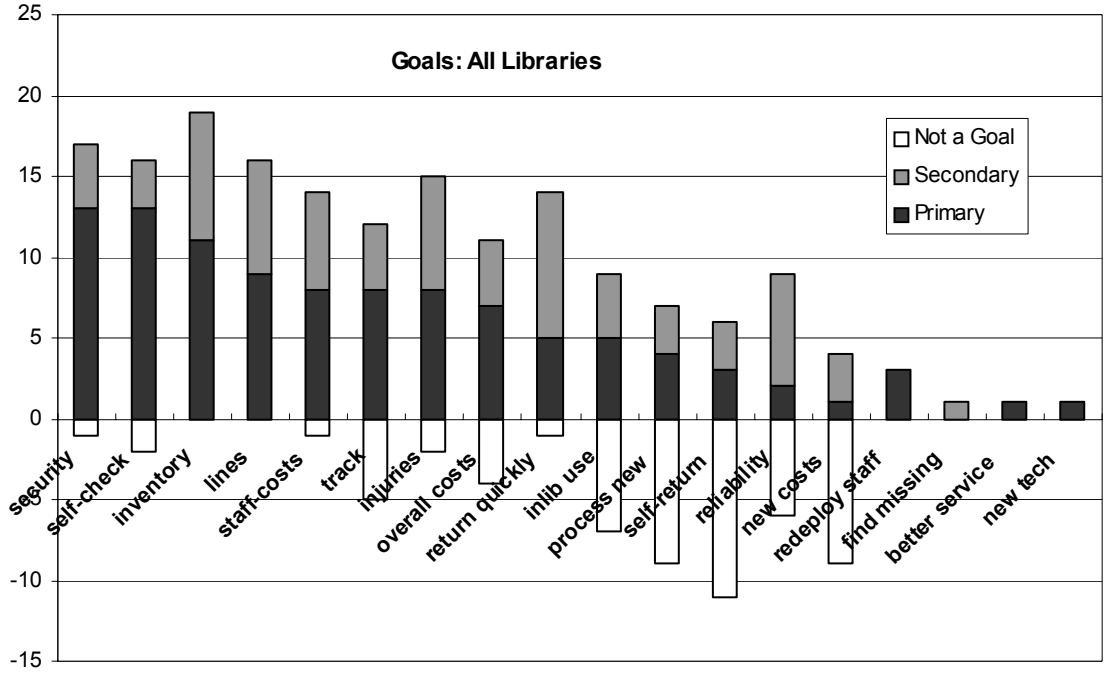
Goal	On the graph as:
Patron self-check out	self-check
Reduce lines at circulation desk	lines

Reduction in circulation desk staff costs	staff-costs
Patron self-return	self-return
Return items to shelf more quickly	return quickly
Reduce staff injuries	injuries
Increase security/reduce theft	security
Increased equipment reliability	reliability
Better inventory control	inventory
Faster processing of new materials	process new
Track in-library use of materials	inlib use
Track materials more accurately	track
Reduce costs for processing new materials	new costs
Reduction of overall library staff costs	overall costs

Interviewees added the following to the list in the "other" cell:

Goal	**On the graph as:**
Provide good service	better service
Increase staff efficiency	redeploy staff
Have an upgrade path for future technology	new tech
Find missing items	find missing

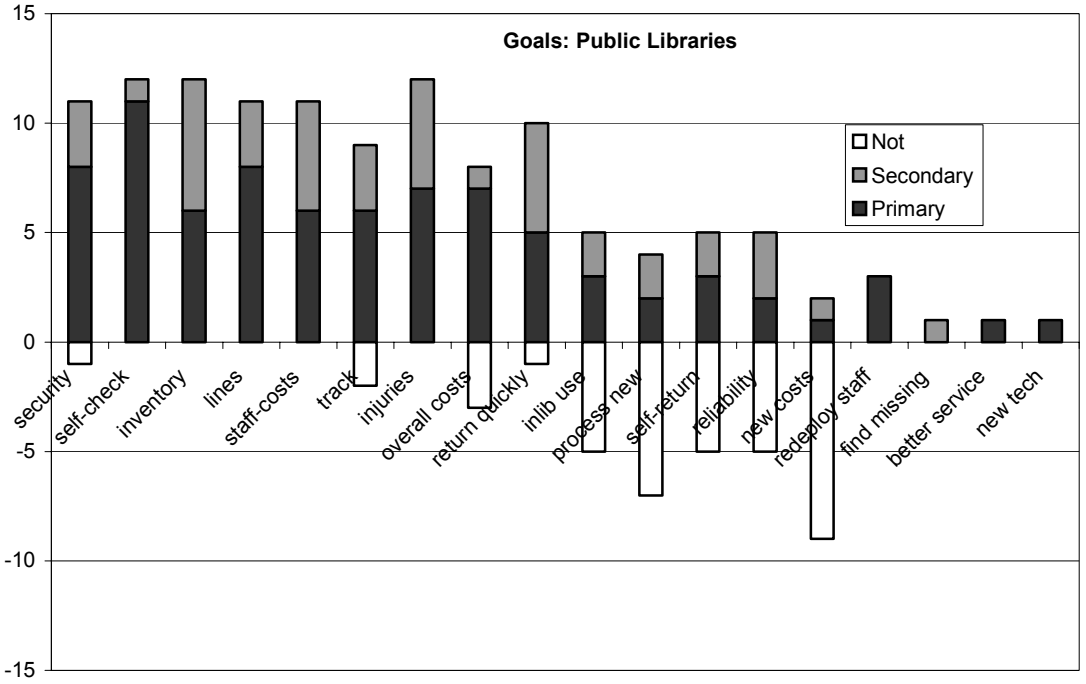
Eighteen libraries responded to the question about goals. They were not required to answer for each goal listed, so for some of the goals the total number of responses is less than eighteen.

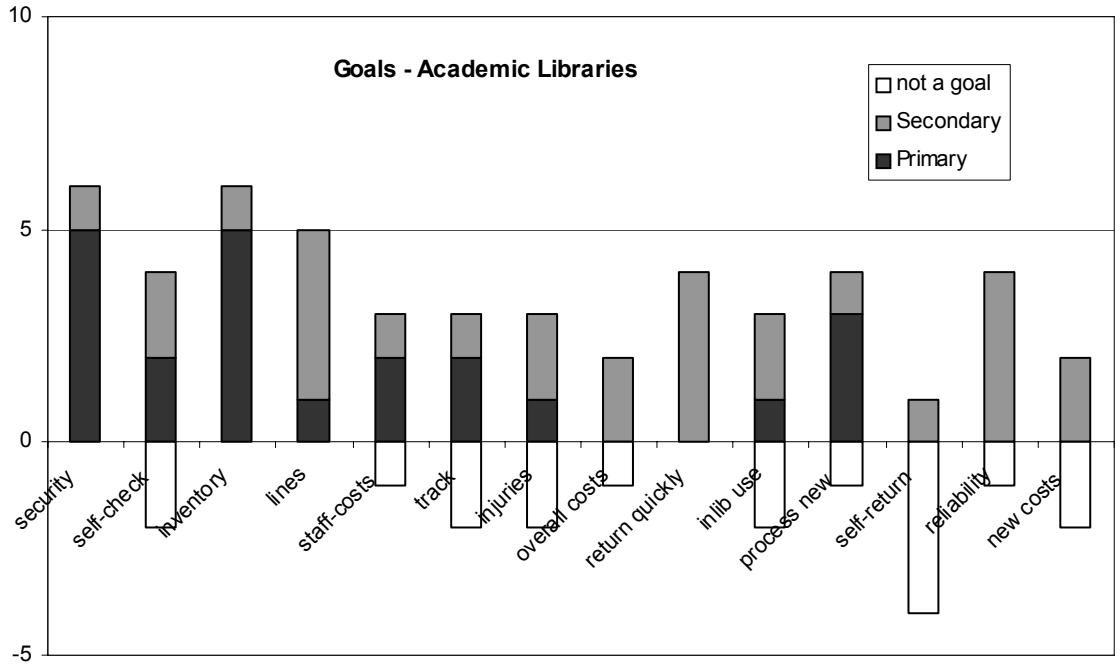


Libraries in our survey were greatly interested in the security capabilities of the RFID systems, and in introducing or increasing the rate of patron self-check. After those, the libraries were hoping to be able to do better inventory control, and reduce lines at the circulation desk. Notably, every library listed inventory control as either a primary or secondary goal, and inventory control and reducing lines were the only goals that were not listed as "not a goal" by any of the libraries surveyed.

On the lower end of the scale, libraries clearly did not expect to lower their costs for processing new books, although some had a goal of decreasing their processing time for those materials. They showed little interest in implementing patron self-return of items, and only some interest in tracking in-library use of materials.

There are significant differences between the goals of the public libraries in our survey and those of the academic libraries. There were seven academic libraries that responded to the goals portion of the survey. They showed less interest in patron services (self-check or reduction of lines at the circulation desk) and more interest in the security and inventory capabilities of the RFID system.


Goals: Public Libraries
Not
Secondary
Primary
15
10
5
0
-5
-10
-15
security
self-check
inventory
lines
staff-costs
track
injuries
overall costs
return quickly
inlib use
process new
self-return
reliability
new costs
redeploy staff
find missing
better service
new tech


Goals - Academic Libraries
not a goal
Secondary
Primary
10
5
0
-5
security
self-check
inventory
lines
staff-costs
track
injuries
overall costs
return quickly
inlib use
process new
self-return
reliability
new costs

Circulation

The primary area for expected cost savings in libraries using RFID is for the circulation of materials. RFID has a number of advantages over the barcode systems commonly in use in libraries.

- Where barcodes are placed on the inside covers of books, the books must be opened at the time of check out and check in to present the barcode to the reading device. RFID tags can be read with books or media cases closed.
- Barcode reading requires the user to align the barcode with the infrared beam. Barcode systems vary in how precise this placement must be, and therefore in the time it takes to align the item for reading. RFID does not require any alignment. Items can be passed relatively quickly across the check out pad in any position.
- Check out and check in with a barcode system must be done on an item-by-item basis as only one barcode can be read at a time. RFID systems can check out and check in multiple items simultaneously, such as when a stack of books is moved across the check-out pad. The number of items that can be checked out at the same time is different with different systems, and is related to the strength of the RFID signal, the strength of the RFID reading technology, and with the size of the items (which determines the distance each tag is from the reading pad).

The need to circulate more books with less staff was a factor for many of the libraries in our survey. More than one library was in the situation of moving into a larger space without receiving a larger staff allocation. Some libraries that had already opened their new or renovated facility reported a great increase in circulation. This was generally attributed to the appeal of the new facility and was often an expected and even a planned result of the library's building program. RFID's possibilities for faster check out for circulating materials and easy to learn self-check out appealed to libraries that will need to do more with the same level, or perhaps even less, staffing.

Quotes:

> "The circulation today is about 16,000 (per year), but we expect that to double with the new building."
>
> "We're moving to a new building which is eight times our current space, and we don't know if we'll be getting any additional staff. We hope that RFID will help with our staffing problem."

Libraries varied in their pre-RFID use of self-check, some not having had self-check systems previously and others having already moved some patrons toward the self-check option using their barcode-based circulation system. The amount of self-check that was expected varied considerably among the libraries interviewed. One library felt that its primarily elderly population would not take well to the self-check stations. Others did not feel that they had optimal solutions for all materials, such as their media collections or their circulating magazines, and that these materials would prevent them from realizing high self-check levels.

Closely related to patron self-check is patron self-return. Self-return systems vary in the amount of patron interaction they require. Some execute the check-in of materials in a way that is invisible to patrons through technology in the book drop. One library in our survey had this type of check-in system. Another type allows the patron to check in the item at a station similar to

the check-out station, provides feedback to the patron that the item has been checked-in and prints a receipt. None of the libraries in our survey were currently using this system. Only six (33%) of the 18 libraries in the second survey were considering the self-return option, while half of them (nine of the libraries) said that this was not a goal for them.

Self-return is sometimes configured as part of a sorting system. One library reported having implemented a sorting system. Five other libraries have purchased this option and will eventually be implementing it. One library reported that their existing branches could not accommodate the space requirements of the self-return/sorting station, although one had been purchased for a library in that same system that was a new construction.

Whether or not they expected to realize a high percentage of self-check, or indeed, any self-check at all, 16 of 18 libraries in our study (89%) stated a goal of reducing lines at the circulation desk. This was based on the expectation that circulation desk staff would be able to check out materials more quickly using RFID.

Looking at the entire "round-trip" of the circulation function, five of the libraries (28%) had as a primary goal to return circulated items to the shelf more quickly, and nine libraries (50%) listed this as a secondary goal. One library stated that this was not a goal.

While libraries generally have figures for circulation rates, they often have no way to count in-library use of materials. This can be especially important for libraries with large reference and "library use only" collections. Five libraries (31%) included the tracking of in-library use as a primary goal, and four (25%) listed it as a secondary goal. Nearly as many libraries—seven (44%) – however, said that tracking of in-library use of materials was not a goal.

More than one library mentioned the potential advantages of RFID for audiovisual materials that are stored in cases or special security boxes. These currently require the staff person to either remove a lock box, retrieve the item from behind the desk, or to open the case at the time of check out to make sure that all of the disks or tapes are present. RFID solutions are expected to allow this check to be done on the closed case as the item is checked out and checked in, thus saving considerable staff time. Some libraries in the survey had not had the capability of self-check for their audiovisual materials but hoped to be able to implement this function with their RFID system.

Increased Security

The security capabilities of RFID were mentioned as either a primary or secondary goal as frequently as circulation goals. With barcode systems, the barcode provides circulation capabilities, but other technology must be used to create an effective security system. RFID is presented as an improvement over the barcode systems because the RFID tag interacts with both the circulation system and the security technology.

There are two primary types of security systems today being employed by RFID system vendors. In the first, the RFID tag has a "security bit" that is activated when the item is checked out. The security gates read the tags as patrons exit and alarm if tags pass through that do not have the security bit properly activated. In the second, there is no change to the RFID tag when items are checked out. Instead, the security gates read the tag and look it up in a record of items checked out to determine the recorded status of the item. If the item is not recorded as "checked out" in that database, the gate alarms sound and a staff read-out identifies the item that caused the alarm.

The "tattle-tape" solution that has been dominant for the past decade or more was seen as unsatisfactory to most of the libraries interviewed. Their concern was not expressed in terms of items removed from the library, but in terms of patron service and staff time. One library stated that the accuracy level of the security gates of their previous system was poor, leading to many false alarms. Because the alarm system could not identify the offending item, staff were required to ask users to empty backpacks or bags in search of the source of the alarm. This was an embarrassing situation for both the patron and for library staff, especially when the alarm turned out to be false. With the RFID system, some libraries in our study reported greater satisfaction with the accuracy of the security system (fewer false alarms), and one stated that patrons who had failed to check out an item were receptive to the library's ability to let them know what library-owned item in their possession had triggered the alarm. This latter feature is a function of the type of interaction between the security gates and a record of all items checked out, which is provided in some vendor systems.

Some libraries had not previously had a security system. Others had a security system that was not amenable to patron self-check capabilities. One library had a previous system that was easy for patrons to circumvent. With their current RFID system, they reported that they were not having that problem.

Quotes:

> "Users are very responsive when told what item is alarming the gates, compared with the old system when we could only tell them that 'something' they have in their bag is setting off the alarm."
>
> "With our previous system, we couldn't use self-check without compromising security. Patrons could turn off the security tag without checking out the item."

Inventories

RFID systems offer the ability to perform inventories using hand-held scanners. This allows a library to do an inventory without having to remove items from the shelves as is necessary when doing an inventory on barcoded items. Few libraries in our study had experience with the inventory capabilities of the RFID system, but every library that responded to our question about goals responded that the ability to perform inventories was a primary or secondary goal. This capability was, however, never named as the single reason for the purchase of an RFID system. The inventory capability requires an interaction between the RFID system and the library's integrated library system (ILS). In some cases, libraries were awaiting upgrades to their ILS that would permit the RFID system to interact with the library database. Other libraries had bought the inventory system but had not yet begun using it. Only one library reported on their experience in using the inventory system. Some intended to perform full inventories using RFID, others are primarily interested in using RFID to inventory particularly the most active areas of their collections.

Quotes:

> "It's been ten years since our last inventory. That one took one and half years, and we found $59,000 worth of materials that had been listed as missing."
>
> "We do inventories in the summer months, but currently it takes three summers to complete a full inventory. We hope with RFID that we can complete inventories in less time."

Closely linked with the inventory function is the potential to use portable RFID wands to find requested items that may be mis-shelved. This capability is seen as increasing service to patrons who place holds on items by making it easier for staff to find the requested items. This could also result in savings because libraries can fulfill requests from their own shelves rather than purchasing duplicate copies or making requests to other libraries. It can potentially reduce the amount of staff time spent searching for items that are listed as on the shelves but cannot immediately be located.

Cost Reduction

A clear majority of the libraries in our survey (78%) saw the reduction of costs for circulation staff or the maintenance of circulation staff levels in the face of higher circulation as a primary or secondary goal. The reduction of cost, or the maintenance of staff levels for overall library staff in the face of greater patronage was a primary or secondary goal for 67%. Only one library did not have a goal of reducing circulation staff costs, and four libraries did not seek to reduce overall staff costs. Check-in of items by staff was expected to be faster, and one library reported that they were expecting the check-in with RFID to be more accurate than it had been with the barcode system. Libraries that anticipated a reduction in staff hours at the circulation desk did not necessarily see that leading to an overall reduction in staff. Many were looking forward to re-deploying staff in other areas of the library, providing a variety of patron services.

> "Plans are to have existing [circulation staff] work closer with the public doing reader's advisory, assisting in the book stack areas, assisting with the online catalog and internet accessible computers, and providing more instruction to library users."

> "We don't expect to change the staffing levels at RFID locations – in particular decreasing the number/hours of staff. In fact most of our rural branches only have one staff person operating the branch. We are running pretty lean as it is and we will continue to use current staff, but RFID efficiencies allow us to redirect their duties to include higher level customer service functions than manual check out."

> "We were able to reallocate staff to the Welcome Desk and to the Reader's Advisory Desk from Circulation."

Reduction of Staff Injury

The reduction of staff injury was cited as a primary or secondary goal by 15 of 18 libraries in the study (83%). Two libraries, both of them academic libraries, stated that reduction of injuries was not a goal. Relief for staff is expected to be achieved through reduction in the frequency of repetitive motions used in checking out materials. Patrons, not staff, will be doing more of the check out, and RFID promises solutions for materials that are stored in cases, such as CDs and DVDs, that do not require opening and closing of their cases during check out and check in.

Materials Processing

A significant minority of the libraries had a goal of reducing the time to process new materials (four had this as a primary goal, three as a secondary). The majority, however, (eight respondents) stated that this was not a goal. Eleven libraries answered that reduction of the costs of processing new materials was not a goal. Four libraries had some expectation that their new materials costs would be lowered.

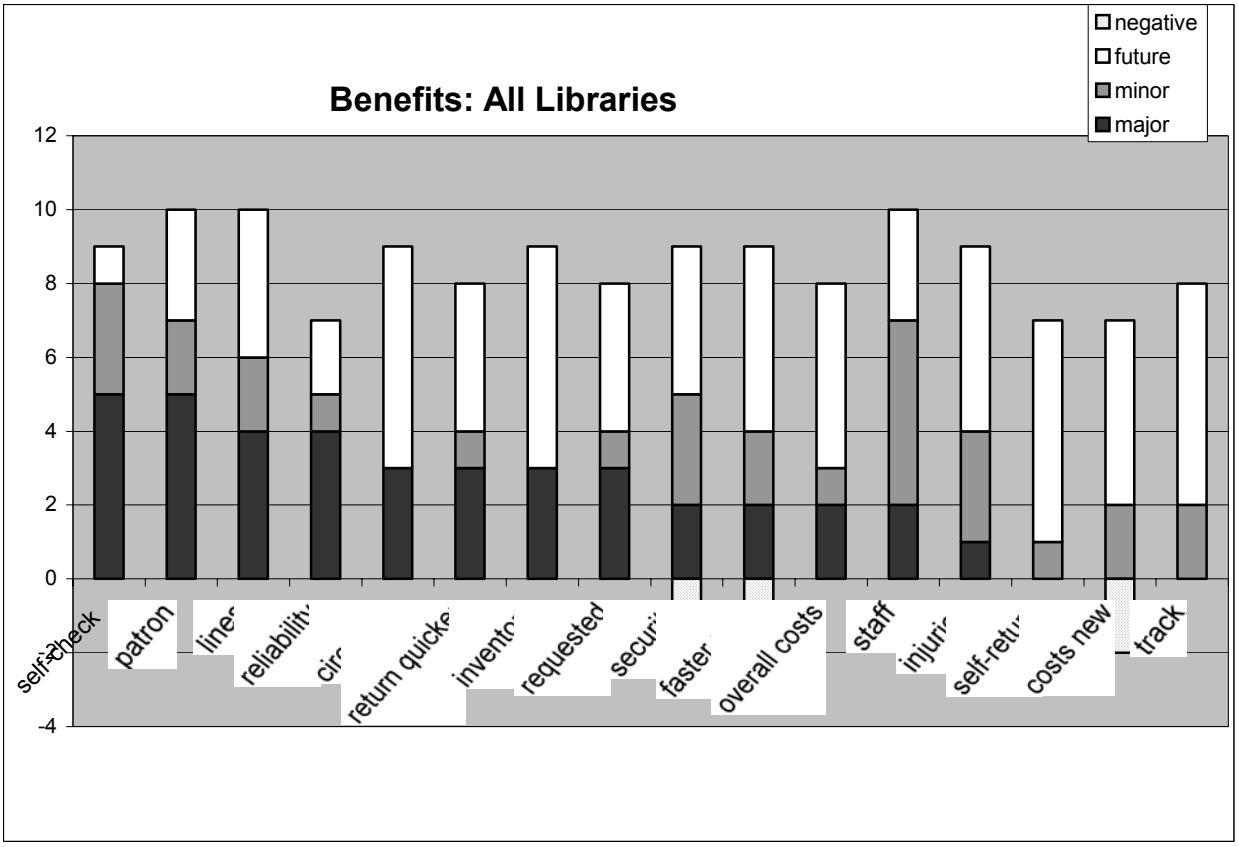
Service and the Future of Technology

Two other goals were volunteered by respondents. The first was to provide "good service" for patrons. It is likely that this goal would have been chosen by others if we had included it in our original list. The second was "interface with future technology."

Benefits/Detriments Realized

The number of libraries able to report on the benefits and detriments they realized from implementing RFID is small, with 9 libraries reporting. Libraries were not required to answer in each category, therefore the number of responses varies from category to category. One library responded that several categories were both a "minor benefit" and a "benefit not realized/possible future benefit", so that the number of responses sometimes totaled 10. The limited amount of data restricts our ability to generalize much about what benefits or detriments other libraries can expect from RFID. The fact that only a subset consisting of 50% of those 18 libraries that reported on goals were able to report on benefits, makes it difficult to correlate results with expectations. As stated previously, the bulk of RFID implementations in California libraries have taken place – with many still in process – from 2004 to the present. A total of 17 of the 24 reporting libraries (71%) began implementation in 2004 or later. Even for those libraries that have finished implementing, some still have parts of the system (such as the inventory module, or the system for checking out AV materials), which have not yet been installed or used. Others plan to expand to other sites within their system, and so have not yet realized the intended scope of their implementation, nor the intended impacts. Even for those mostly or fully implemented, the track record is short, and the full realization of the potentials and drawbacks of the system may not yet be completely apparent. Within these limitations, the experiences of other libraries can still provide some useful information for those considering RFID adoption.

Surveyed libraries were asked to indicate what results they realized from RFID implementation. They were asked to classify these results as a major or minor benefit, a possible future benefit/benefit not realized, or as a negative impact. Note that some categories add up to 10 because some libraries marked both "minor benefit" and "possible future benefit" possibly because they expected that the benefit would increase beyond the level currently attained.



The most reported benefit cited by libraries in our study was patron self-check and patron satisfaction. Five of nine libraries (56%) reported self-check as a major benefit. Patron self-check was cited as a minor benefit by another 3 libraries (33%). 5 of 10 responses (50%) listed patron satisfaction as a major benefit while two libraries (20%) listed it as a minor benefit. After those, the reduction in lines at the circ desk and increased equipment reliability were listed by four libraries as major benefits. Four libraries noted detriments associated with RFID adoption. Two libraries found that that they were unable to reduce costs for processing new materials once they implemented RFID. One library was unable to process new materials faster, and another library noted that they did not increase security/reduce theft.

Circulation

Self check

Major benefit**:** 5 libraries 56%

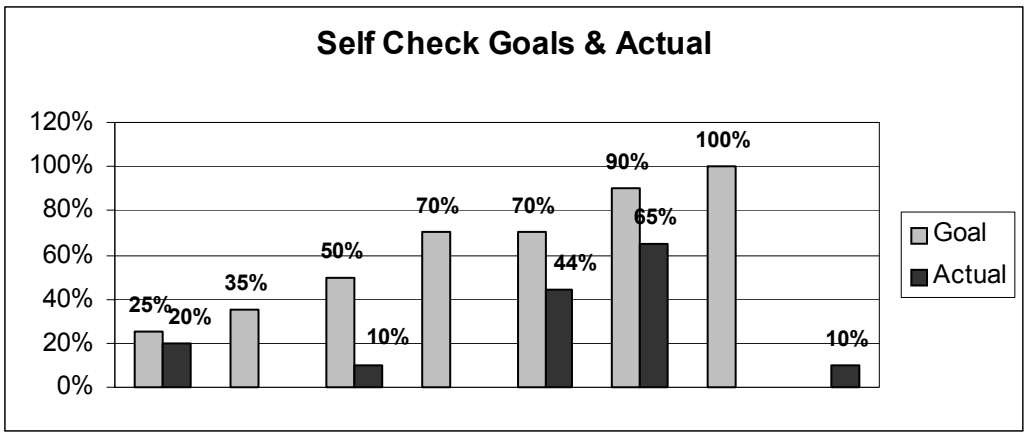
Minor benefit: 3 libraries 33%

Not realized/possible future benefit: 1 library 11%

As many libraries had expected in their goals, patron self-check has yielded one of the two most reported benefits for implemented libraries – patron satisfaction being the other one. Eight of the 9 reporting libraries (89%) reported that patron self-check was either a major or minor benefit for them. The same percentage of libraries had reported this as a goal. As noted above, not every library's primary goal was to move to self-check; this tended to be a major goal for public libraries but not necessarily for academic libraries. Those libraries with a goal to move to

or expand self-check were asked about the percentage of circulation they expected, and the amount they achieved.

The table below displays this data.



Seven libraries reported a percentage goal for self-checks that varied from 25% to 100%. Five libraries reported realized percentages from 10% to 65%. Because of the still-in-process character of many of these implementations, some libraries indicated that they would be able to up their percentage of self-check achieved once they implemented or finished implementing their AV materials self-check systems, for example, or made other changes such as putting out their holds for patron self pick-up. Given that, it would be interesting to re-survey libraries again in the future to see if they have in fact reached their self-check goals. That would give us a better measure of whether RFID systems can reach the potential which libraries expect of them.

Reduction in lines at circ desk

Major benefit:	4 libraries 40%
Minor benefit:	2 libraries 20%
Not realized/possible future benefit:	4 libraries 40%

The reduction in lines at the circulation desk was reported on by 10 libraries. (One library responded under two headings.) Some libraries reported that an increase in self-check activity reduced the length of the lines, as more patrons checked out their own materials. Another library indicated that, while they did not purchase self-check machines, staff was able to check out materials more quickly with RFID, thus reducing lines. They pegged this increase in speed as being twice as fast as their previous system for books and AV items and 3 times faster when multiple AV items were checked out. One other library noted the increased speed of staff-assisted check out as 3 times faster than before. However, the fact that 4 of the 10 responses did not see shorter lines, and that this was a major or minor goal cited by 89% of the 18 libraries surveyed, indicates that the results has not yet matched expectations.

Patron self-return

Major benefit:	0 libraries
Minor benefit:	1 library 14%
Not realized/possible future benefit:	6 libraries 86%

Patron self-return was not a goal for the majority of the libraries surveyed. Fittingly, it was not realized as a major benefit by any of the libraries. A total of six libraries in our study intend to implement sorting systems, but only one library has done so. Thus, patron self-return is still a work in progress, with benefits and detriments not yet experienced by the majority of libraries that hope to implement it. It is worth noting that patron self-return has been implemented in libraries even without a sorting system. The most usual option is an RFID reader in the book drop that checks items in as they are returned.[5] A few libraries have also used machines just like self-checks to allow patrons to return items inside the library and receive a receipt for them as they check in.

Information about the time spent by staff checking in materials was reported by three libraries. All three of them (100%) reported that staff check in was quicker with RFID. One library reported that two to four times as many materials could be checked in per hour with RFID. A second library reported the improvement at 2 to 3 times faster. The third library, which employed a sorting system, said that check in was now 10 times faster, and automated returns had reached 85%.

Returning items to the shelf more quickly

Major benefit:	3 libraries 38%
Minor benefit	1 library 13%
Not realized/possible future benefit:	4 libraries 50%

The assumption here is that the quicker check-in of materials will allow libraries to reshelve items more quickly. One library with a sorting machine reported than even in their environment, where circulation has almost doubled (when they moved into a new building), they now have a turn around time of only 12 hours. Previously they had set their ILS at 72 hours for "being checked in" or "in transit" messages. They reduced that number to 36 hours, then to 24 hours. This goal was cited as a major one by 33% of libraries and as a minor one for 60%.

Patron Satisfaction

Major benefit:	5 libraries 50%
Minor benefit:	2 libraries 20%
Not realized/possible future benefit:	3 libraries 30%

The total adds up to 10 because one library reported it as both a minor benefit and a possible future benefit/benefit not realized. This result is particularly interesting, given the controversies about RFID and privacy. Apparently, among the libraries surveyed, most have patrons that are happy with the system.[6]

Security

Major benefit:	2 libraries 20%
Minor benefit:	3 libraries 30%
Not realized/possible future benefit	4 libraries 40%
Negative impact	1 library 10%

Libraries reported on the security functions of RFID. Ten responses were received because one library listed it both as a minor benefit, and as a not realized/possible future benefit, indicating,

perhaps that they expected some further development in their implementation in regard to security. It would have been interesting to learn more about the report that there was a negative impact, but the library did not provide responses to further questions about this issue. One of the libraries that reported it as a minor benefit remarked that "particularly popular YA materials" are still being stolen, that some tags have been ripped out,[7] [8] and some DVD and CD cases have been pried open. One library did note that there were less false alarms with RFID security gates.[9] The efficacy of RFID security gates in detecting material that has not been checked out has not been addressed by any library in our study. One author has noted that the distance between the gates may be problematic for RFID tags that ideally need a closer range (12" to 14"), than security gates provide (typically 18" to 22" from the center of the gate).[10] Another author says gates may have trouble reading many tags from a stack of materials going through the gates.[11] Libraries had strong expectations that security would be improve with RFID. Both security and patron self check had the greatest number of libraries listing them as major goals, with 13 libraries each (72%). Four libraries (22%) reported security as a minor goal. Only 50% (combined major and minor benefit) of libraries reported that increased security/reduced theft was realized as a benefit, while 94% expected it as a goal (combined major and minor).

Inventories

Major benefit: 3 libraries 33%

Minor benefit: 0 libraries

Not realized/possible future 6 libraries 67%

The libraries that reported this as a major benefit were the only ones that had some experience with the inventory system. Many libraries had purchased systems but had not yet implemented the inventory module. None of the libraries reported having done a complete inventory yet. One library said that they had been using it for their "missing" and "claimed returned" items. Another library said that previously they used barcode wands which did not work well, and they ended up keying things in by hand. This led to a lot of mistakes. More information will have to be gathered about the possible benefits of the inventory system in the future as more libraries make use of it.

Tracking of in-library use of materials

Major benefit: 0 libraries

Minor benefit: 2 libraries 25%

Not realized/possible future: 6 libraries 75%

Another function of the inventory system is the tracking of materials used in the library. Because of limited experience with the inventory system, there has not been much benefit reported for this activity.

Better service for requested items

Major benefit: 3 libraries 38%

Minor benefit: 1 library 13%

Not realized/possible future: 4 libraries 50%

There are a number of reasons why RFID systems could provide better service for requested items. One of them is the inventory module's ability to find misshelved items more quickly.

Another is that the quickness of check-in provides libraries with the ability to turn around requested items more quickly, getting them into patron's hands in a shorter time. Libraries did not provide more specific comments on this category; it would be interesting if we had more information on what aspect of RFID accounts for this benefit.

Reliability of Equipment

Major benefit:	4 libraries	57%
Minor benefit:	1 library	14%
Not realized/possible future:	2 libraries	29%

The only specific comment received on this topic was from one library that said their "accuracy rate has improved with fewer 'claims returned' complaints from patrons."[12] It would have been useful to have more information about this topic from libraries since "reliability" can refer to a number of things – accuracy, less down time, and longevity of equipment for instance.

Cost Reduction

Circulation staff

Major benefit:	3 libraries	33%
Minor benefit:	0 libraries	0%
Not realized/possible future:	6 libraries	67%

A reduction in circulation staff costs were reported after implementation by 3 of the 9 libraries. Given the interest in this goal (by 78% of the libraries), the result so far has not matched expectations.

Overall library staff

Major benefit:	2 libraries	25%
Minor benefit	1 library	13%
Not realized/possible future:	5 libraries	63%

In terms of the reduction in overall staff costs, two libraries reported that this was a major benefit.

Reduction in Staff Injury

Major benefit:	1 library	11%
Minor benefit:	3 libraries	33%
Not realized/possible future:	5 libraries	56%

One library that reported a minor benefit in this area commented that previously they had staff that had complained about arm and wrist pain, but currently there was no one with any injuries. Eight of 17 libraries (47%) had indicated that reduction in staff injury was a primary goal for them, and seven (41%) more had said it was a secondary goal.

Staff Satisfaction

Major benefit:	2 libraries	20%
Minor benefit:	5 libraries	50%

Not realized/possible future: 3 libraries 30%

Staff satisfaction with the RFID system was reported by a majority of libraries. One library commented that circulation staff really like the system because the lines are shorter and they no longer have to deal with frustrated patrons. Another library reported that the staff interaction with patrons was more pleasant when the gates alarmed since staff was able to let patrons know which item was alarming the gates.

Detriments

Negative impacts**:** 4 libraries

Four reports of detriments or negative impacts were received about the implemented RFID systems. This is a small number in relation to the benefits that were reported. The same cautions about the preliminary nature of many implementations and the small data size also apply to the information about negative impacts. With a larger number of implementations and a longer track record, there will likely be more information about detriments. Two libraries reported that they were unable to reduce the costs of processing new materials. Two other libraries reported that they were able to reduce costs and that it was a minor benefit. One library indicated that they were unable to save time in the processing of new materials. Two libraries reported this as a major benefit, and two reported this as a minor benefit. Most libraries, however, did not start with a goal either of reducing the cost or the time needed to process new materials. Finally, as mentioned above, one library reported that they were unable to increase security/reduce theft with RFID. In view of the importance of this as a goal for so many libraries, it would have been helpful to have more information about this particular library's situation.

Costs and Benefits/Savings

The above reviews the responses about goals, benefits and detriments of RFID systems in those libraries that responded to our survey. This section will look at what the implications of these results are in terms of costs and savings expected from RFID. Below, are listed various categories of costs and benefits that should be considered when evaluating RFID. Ideally, libraries can make some projections based upon their own situation and the limited data provided from these surveys that can help them to determine if benefits, both in the form of savings and in quality of service, outweigh costs.

Many of the same cautions apply to extrapolation about costs and savings from the small pool of data obtained from this survey. It is very difficult to generalize about costs and benefits that result in cost savings when looking at the institutions in our study. Each library was in a unique context in terms of their pre-RFID systems, in terms of their goals for purchasing a new system, and in terms of the needs of the community that they served. In thinking about whether to implement a new system such as RFID, libraries need to ask themselves what the costs and benefits will be compared to their present situation.

A common opinion voiced in the library community is that RFID is an expensive solution compared to the technology of barcodes that has been fairly standard in libraries for nearly two decades. To test this hypothesis, one can look at the comparative costs of today's standard system that combines barcodes for identification and an electromagnetic system for security with an RFID system of the same size and scope. The cost relationship between the two will change, however when a greater number of tags are bought. The tags, and not the equipment, (perhaps with the exception of a large sorting system) turn out to be the expensive portion of RFID implementation.

Cost Comparison: Barcodes with EM v. RFID

For libraries with new or renovated facilities that will need to include the purchase of a tracking and security system in any case, the question is: what is the relative cost of using barcodes for tracking combined with an electromagnetic system for security versus the cost of a system that uses RFID for both? The cost of the EM system has been determined by querying some library vendors about the cost of their equipment and supplies. RFID costs represent an average of the costs reported by the libraries in this survey.

Costs vary for both types of systems depending upon the specific library conditions, the vendor and the changing marketplace. The variety of solutions (and hence variation in cost) is more pronounced with RFID due to the newness of the technology. For instance, some vendors require purchase of a server, others do not. Changes have also been made in the EM systems, in part due to the influence of RFID systems. Vendors, trying to compete with the ease of use and patron-friendliness of RFID checkout are attempting to make their systems easier to use, more intuitive.

The costs cited below are based upon a hypothetical library with a collection size of 60,000 and circulation of about 300,000 items per year. Media makes up about 10% of the collection. It is assumed that 80% to 90% of checkouts are done unassisted, via the self-check machines. A certain reasonable redundancy is provided in the equipment as back up: For example, light pens are provided as back up to scanners for barcodes that do not read well. An extra RFID staff check out station is provided as back up to the self-checks. We also assume that the same

number of check out and return stations are needed, although with the difference in the speed at which items can be scanned this may not be the case in an actual implementation.

The equipment included below was chosen to provide like service. Features were included in both systems to enable self-check of books, videos, DVD's and CD's. Still, there are some differences in the operation of the EM/barcodes and RFID systems. Multiple items can be checked out and checked in at the same time with RFID, making it significantly faster, while items must be lined up with and passed over the scanner and desensitizer one by one with EM systems. Most RFID systems allow verification and identification of contents of DVD and CD boxes without opening the box. With barcodes and tattle tape, staff must open each box to be sure that an item, and the correct item, is contained in the box. Or, to assure security and correct contents, lock boxes are used. The cost of lock boxes have not been included in the total supply costs below, had it been, the gap in the cost of supplies between the two systems would be very narrow. At between $4.24 and $5.18 per case, the EM system supplies would approximate the cost of the RFID supplies. If lock boxes were used, AV tattle tape could be excluded, resulting in a savings of about $9,000 for EM supplies. In a library with a large AV collection, and/or with high circulation of AV materials, the difference with an EM system can be significant in terms of the amount of staff time needed to process AV returns, to assure correct check-out of AV items, and/or to lock and unlock the boxes.

Not included in the costs below are the RFID inventory scanners – at an average cost of $4,495 – because there is no parallel capacity available with EM systems. The RFID portable inventory scanners allow libraries to find missing, reported lost, items on hold, or to inventory the entire collection without removing the items from the shelf. It is not in the scope of this survey to compare the costs and benefits of an EM system and an RFID system. This would be an interesting area for future study.

COST COMPARISON – EM & RFID SYSTEMS

	EM			RFID		
	unit cost	**number**	**extended cost**	**Average unit cost**	**number**	**extended cost**
EQUIPMENT						
Self-check out unit	$16,000.00	3	$48,000.00	$15,335.00	3	$46,005.00
Self-check video module	$2,000.00	3	$6,000.00			
Staff check out stations	$6,000.00	2	$12,000.00	$4,747.00	2	$9,494.00
Staff return stations	$10,100.00	2	$20,200.00	$4,747.00	2	$9,494.00
Resensitization Machine	$3,150.00	1	$3,150.00			
Light pens	$75.00	4	$300.00			
Manual unlocker for AV				$45.00	4	$180.00
Book gates -one aisle	$5,300.00	2	$10,600.00	$4,347.00	2	$8,694.00
Tag programmers				$3,823.00	3	$11,469.00
AV linking station (some systems only)				$3,823.00	1	$3,823.00
Total equipment			**$100,250.00**			**$89,159.00**
Server (some systems				$14,106.00	1	$14,106.00
do not need them)						
SUPPLIES						
Barcodes	$0.04	60,000	$2,400.00			
Tattle tape-books	$0.18	54,000	$9,720.00			
RFID tag-books				$0.68	54,000	$36,720.00
Tattle tape-AV	$1.51	6,000	$9,060.00			
RFID tag-AV				$1.08	6,000	$6,480.00
AV cases for RFID (some systems only)				$1.00	6,000	$6,000.00
Cover labels				$0.04	60,000	$2,400.00
Total supplies			**$21,180.00**			**$51,600.00**
Lock boxes-1/3 CD's, 2/3 DVD's (not included in total below)	$4.24/ $5.18	2,000/ 4,000	$29,200.00			
Total equip & supplies			**$121,430.00**			**$140,759.00**

Implementation Costs

Libraries reported on the cost of equipment and supplies necessary for implementing their RFID system.

Equipment and supplies

Data set: 23 libraries reporting in at least some categories of cost

Average costs of supplies and equipment for the surveyed libraries have been noted in the section on the comparison of RFID and EM systems, and are repeated below. Highest and lowest costs for each item also appear in the table. The average costs can only serve as a very rough guide to help estimate what costs might be for any given library.

	Tags: Book	Tags: AV	Gates: cost per gate	Staff check out/check -in station	Self-check stations	Tag programmer	Inventory scanner	Server (only some systems)
Aver	**$ .68**	**$1.08**	**$4,347**	**$ 4,747**	**$15,335**	**$3,823**	**$4,495**	**$14,106**
Low	$ .47	$ .60	$2,500	$ 1,800	$ 2,854	$1,500	$1,090	$11,500
High	$1.10	$ 1.62	$7,000	$16,031	$20,795	$8,762	$6,125	$16,000

There is no way to give the "typical" cost of a system, because costs vary between vendors, and the needs and goals of each library are different. For example, the number of check-out stations will vary based upon the self-check out goal. One vendor uses a server (whose cache compares items going through the gates with those checked out, and alarms the gates when there is not a match), while other vendors do not require one, since they use an on/off "switch" on the tag itself (tag is turned off when check out, turned on when checked in). Sorting systems were not included in the average cost because of the very small sample size and the huge disparity in cost due to the differing size of the systems. There is variety in the methods of dealing with AV materials too. Some vendors use a "booster" tag to improve read of AV materials, necessitating the use of two tags per AV item. Another vendor uses a lock box on AV material (in addition to the tags), with a device that unlocks the box at the self-check station.

Tagging/ Conversion

Data set: 12 libraries reporting in at least some categories

Staff Time

Average time: 1 minute per item

The time to tag an item varied in the way it was reported as did the tasks associated with tagging. Some libraries reported the time it took to get the item from the shelf to the tagging station, tag it and return it to the shelf. Others counted only the time it took to tag the item once it was at the station. A number of libraries used the opportunity, with the item in hand, to assess it for condition and possible weeding, which lengthened the time spent per item. Some libraries had a lot of jacketed books that needed to have their jackets cut and then re-taped in order to allow

the space to affix the tag. One library reported that the opening day collection for their new building was going to be pre-tagged by their book vendor. Another library used preprogrammed tags with new barcode numbers. Printing the barcode number and affixing it and the tag took very little time – approximately 5 seconds. Aside from this last example, all other libraries used tags that had to be programmed, and the time to tag one item varied from .33 minute to 2 minutes. The average time was just over 1 minute per item. In general AV items took longer, because two tags might have to be affixed, or the item might need to be repackaged in the locking box.

Libraries were also asked about the duration of the tagging effort. This measure is hard to utilize in a meaningful way because it is dependent upon a number of things: the size of the collection, how many staff or volunteers are tagging, how many hours a day tagging is done, whether the tagging is continuous or stop-and-start, and what the deadline is. The smallest collection tagged was 3,500 items; the largest was over 500,000. Often, tagging was done in advance of moving into a new building; the closer the move-in day, the more hours of effort were expended. In any case, the duration of the tagging effort ranged from 4 months to 12 months. Estimated – and in many cases, very roughly estimated – number of hours spent tagging varied from 300 to 10,600 person-hours.

Labor costs

Labor costs also varied greatly from library to library, depending upon who did the tagging and how large the collection to be tagged. Libraries tagged using some or all of the following:

- Staff – all levels or only certain staff
- Volunteers
- Temporary personnel – students (academic libraries) or other temporary workers

Libraries most often used staff – some from all levels, others only circulation or lower paid staff – to tag. Sometimes volunteers were also used to supplement staff efforts. Occasionally, temporary personnel were used. One library had new books tagged by the book vendor. Costs were calculated roughly, and often quite some time after the tagging effort was finished. Many libraries just gave an average cost per hour based upon a middle range staff salary. Other libraries just gave a cost for additional personnel – work-study students or temporary hires. When total costs were reported, they ranged from $4,200 to $223,000. The difference in reporting and the lack of data makes it impossible to generate meaningful cost figures. And there is a legitimate question of which labor costs to include: Some libraries felt that they should not count the cost of regularly scheduled staff, who in any case would be paid for their time. These libraries only counted additional costs for outside labor. Other libraries included staff costs, assuming that time spent tagging meant that staff could not be doing other duties.

Other implementation costs

Libraries were asked about other costs associated with implementing RFID which included

- Training – staff and patrons
- Installation
- Other – pre-implementation costs for researching vendors, issuing RFP

Costs to train staff and patrons in the use of the equipment turned out to be quite insignificant. When cost figures were supplied they ranged from $750 to $2,044. Libraries agreed that the procedures for tagging were simple and that the use of the equipment for circulation and security likewise was not difficult for staff and patrons to learn.

Installation of the equipment by the vendor was also fairly modest, and naturally varied according to the amount of equipment bought. Of those libraries that reported a cost for installation, the range was from under $2,000 to over $9,000. Again, no "typical" cost can be assumed, given the variation in type and quantity of equipment at different libraries.

One significant cost, which strictly speaking was a pre-implementation cost, was for the amount of time associated with putting together the RFP for RFID vendors. Two libraries indicated that significant time was spent by higher paid staff to gather information necessary to put together a well-informed RFP. This cost was estimated at $5,000 and $10,000, respectively. To understand what they wanted, the technology had to be explored carefully. Vendors were questioned, interviewed, and re-questioned. Other libraries were interviewed, on line listservs and blogs were checked.

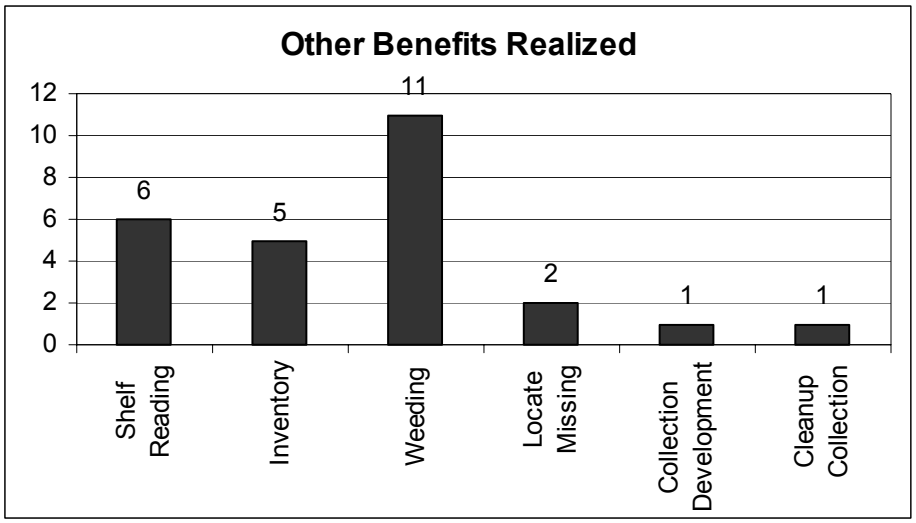
Implementation Benefits

Tagging/Conversion Benefits

Data set: 12 libraries reporting

Libraries were asked whether any benefits accrued from tagging the collection. The benefits tended to be difficult to value monetarily. They included:

- Weeding the collection
- Shelf reading
- Inventorying the collection
- Other-collection development, locating missing items, cleaning up the collection



The benefits were associated with the opportunity to handle the entire collection, a chance afforded only infrequently to libraries. 11 of the 12 libraries (92%) responded that the ability to

weed the collection was a benefit. Half the libraries also felt that tagging brought them the opportunity to shelf read the entire collection, while just under half welcomed the opportunity to inventory the collection. Also mentioned was the chance to locate missing, incorrectly shelved or owned-by-another-site items on the shelf. The recovery of items could certainly be a cost savings and an aid to collection development. The magnitude of this benefit was not quantified by any library surveyed. Finally, cleaning up the collection and aiding collection development were also mentioned as benefits.

On-going Costs

Tagging

Data set: 4 libraries reporting

The cost of on-going tagging often was identical or very close to the cost of supplies initially. Tag costs (exclusive of AV materials) ranged from $.50 to $. 70. AV tag costs were $.70 to $1.62. Cover labels cost $.04 to $.06 . AV boxes (for those systems that use them) were $1.05 a box. The only difference to consider with new materials is that the cost of processing with any previous system (EM or other) will no longer apply, thus creating a cost offset. If there was no previous tracking or security system, then, obviously, there would be no offset cost. As reported in the section, above, that compares the cost of supplies for EM systems and RFID systems, the cost of tags and labels for continuing RFID operations is greater than for an EM system. However, the cost of preparing AV material may be less, depending upon what system is used.

Time needed to process materials with RFID was reported at 3 of the libraries to take longer than with their previous system. Processing a book required from 30 seconds to 1 minute more. Processing AV materials took 30 seconds to 3 minutes longer (the latter because re-boxing in RFID locking boxes was required). One library reported that the time to process each item was shorter with RFID than with the previous system This library reported 1 minute less for book processing and from 1 to 2.5 minutes less for AV materials, unless it was a multiple volume set, in which case the processing time was the same with both systems.

Equipment Maintenance

Data set: 2 libraries reporting

Only two libraries reported on the cost of a maintenance contract with their RFID vendor. Typically, cost is a percentage of the contract. Since the amount of equipment and hence the size of the contract will vary greatly from site to site, suffice it to say that maintenance costs need to be considered. If another system was owned previous to the RFID implementation, then its annual maintenance cost will be an offset to the RFID system's annual maintenance cost.

It is too soon in the life cycle of RFID equipment to estimate its longevity. Both the durability of the hardware and the limits in the ability to upgrade the software to provide greater or different functionality are currently unknown. A library's concerns about privacy may drive changes in the way data is kept or read on the tags. If these changes cannot be accomplished without replacing existing tags, through changes either in software or hardware, RFID systems will become extremely expensive for early adopters and impractical for others.

Ongoing Benefits

Patron self-check and staff assisted check-out

Data set: 5 libraries reporting in detail

Of the benefits reported in detail, which of them are likely to result in cost savings? The initiation of patron self-check, or the increase in the percentage of self-check with RFID can lead to cost savings for libraries. Even staff-assisted self-check can reduce the time it takes to check-out materials, thus increasing staff productivity. Five libraries reported in detail about circulation staffing and rapidity of check out before and after RFID implementation. With only 10% patron self-check, one library reported a reduction of 1 staff person per hour at the circ desk – their baseline of 3 to 4 staff per hour (between peak and non-peak times) was reduced to 2 to 3 staff per hour. (This same library reported that the reduction in circ desk staff costs was a possible future benefit. Perhaps they are expecting further changes? They did not provide more information on this.) A second library reported a reduction of 2 staff per hour from a baseline of 3.5 to 1.5 FTE per hour. Another library that did not specify their self-check percentage reported 1/3 less staff hours at the circulation desk. The fourth library reported a savings of .625 FTE per hour on a baseline of 2.875 FTE, with a self-check percentage of 44%.

Average staff/hr Circ desk- before	**Aver staff/hr Circ desk- RFID**	**Change**	**Percentage self check w RFID**
3.5 FTE	2.5 FTE	1 FTE less	10%
3.5 FTE	1.5 FTE	2 FTE less	67%
201 hr per week	134 hr per week	67 hr less per week	Unknown
2.875 FTE	2.25 FTE	.625 FTE less	44%

The last library, which did not implement self-check reported on the time it took to for staff to check out items. It was twice as fast as previously for books and AV materials, and 3 times faster when multiple AV items were checked out. Staff-assisted check out, according to another library was 3 times faster with RFID than with their previous system.[13] Both increasing the amount of self check and staff-assisted check out can result in reducing staff assigned to the circulation desk. For libraries with very small staffs and only one person assigned to the circulation desk per hour, staff may be able to divide time between check out and other activities, thus increasing productivity.

Some of the libraries reported that they not only decreased the number of staff at the circulation desk, but that they did this at a time when circulation was increasing. Thus, the net effect is to both save money by reducing staff and increase productivity for the remaining staff.

Figuring Staff Costs Savings/Value of Productivity Gains

Possible staff savings related to check-out activities can be realized in the following ways:

1) Reduce number of circ staff per hour assigned to circ desk. Often staff is reassigned to other, higher level duties.
2) Increase productivity when the same number of staff checks out more items per hour in an environment of rising circulation (often found when moving into a new facility).

3) Divide circ staff time between circ desk and other activities.

Here is an example that illustrates both #1 and #2 above: A library reports that their circulation increased tremendously when they moved into a new building. In addition, they reduced the number of staff on the circulation desk by .5 FTE . Before moving and installing the RFID system, circulation was 1,500,000 items. It increased to 2,000,000 items after the move. If we divide the circulation per year by the number of open hours (3,208) per year, we get the number of items circulated per hour – 468 and 623, respectively. Before moving, they had an average of 3 FTE at the circulation desk. After the installation, they had 2.5 staff on the desk. Assume the cost of each staff person (including benefits) is $25 per hour. Divide the total circulation desk staff cost per hour by the number of items circulated per hour to get the cost of circulation per item

Before installation: $75/468 equals $.16 per item

After installation: $62.50/623 equals $.10 per item.

Before installation it cost the library $240,000 in circulation desk staff costs. ($.16 per item x 1,500,000 items)

After installation it cost the library $200,000 in circulation desk staff costs ($.10 per item x 2,000,000 items.

However, if we want to understand the real value, we would have to figure what it would have cost the library to circulate the greater amount of materials at the old level of efficiency (that is $.16 per item x 2,000,000). We get $320,000. So the savings caused by the gain in efficiency is $120,000.

Add to that the .5FTE, in staff savings on salaries, since they are paying less people per hour to staff the desk. At $25 per hour x 3,208 open hours/ 50% FTE= $40,100.

$120,000 gain in efficiency (staff not hired)

$ 40,100 .5 FTE staff at circ desk

$160,100 yearly savings/increased value

Staff assisted check-in

Data set: 4 libraries reporting

Staff -assisted return times also showed productivity gains. One library was able to check in 2 to 4 times more material per staff hour, previously checking in 1 to 2 trucks per hour, now 4 trucks in the same time. Another library reported book check-ins were 3 times faster, single AV items were 60% faster, and multiple AV items were unchanged. A third library said they were able to reduce the number of staff sorting hours modestly, by 16 hours a week (baseline had been 298 hours per week, now 282 hours per week.) The fourth reporting library had a sorting system. While this is not staff-assisted check in, it is interesting to report the results: They indicated that it used to take 10 seconds to check in an item, and now with the sorting system it took only 1 second. The number of staff was modestly reduced from 2 per hour to an average of 1.5 per hour.

The same type of calculation, shown above, could be done for check-in staff. There may be staff savings, productivity gains or both.

Security

No libraries reported in detail about the cost value of RFID in relation to security. Indeed, the results reported about general benefits so far on security are disappointing. The most value, no doubt, will be realized by libraries that had no previous security system. The difficulty in assigning value or cost savings is that libraries usually do not have a clear picture of their current loss rate.[14] Without the ability to do periodic inventories, libraries often do not know how much material is lost or stolen. One vendor[15] has put together a method for assessing loss rate by doing a sample of 175 titles. But without before and after information on loss rate, the value and efficiency of RFID security gates is difficult to judge.

Returning items to shelves more quickly/Better service for requested items

We received no in-depth information about this benefit from which we could extrapolate savings. However, if materials are checked in and turned around more quickly, it is conceivable that libraries can reduce the amount of duplicate copies they need to purchase, or lessen costs associated with transiting materials requested from other branches in the system or from other systems. Quicker turn around times can also produce better service for requested items, as items move more rapidly from the book drop to the "holds shelf." As noted before, the ability to find requested items may also increase with the implementation of the inventory system. If staff spends less time searching for requested items, this too can produce cost savings as well as greater patron satisfaction.

Reduction in staff injuries

No cost related information was received from surveyed libraries on this item. If libraries can reduce the amount of repetitive tasks that staff must do – such as checking out materials – there can be a reduction in repetitive strain injuries and possible cost savings. Referring to a study done by a library, Smart[16], reports on the number of "risky motions" repeated each hour by staff in doing circulation functions.

Reliability of equipment

This area too, may be one in which cost savings can accrue to libraries. Unfortunately, we did not receive specific information about how the equipment was deemed more reliable, nor about possible cost savings. One can conjecture only that if there are fewer breakdowns, staff will not be reduced to checking out materials by copying barcodes for example. This would certainly save time, money, staff and patron frustration. Reliability may also mean better accuracy, which one library did mention, or better detection at the security gates. With the limited information available, and the short time most equipment has been in use, it is hard to quantify this benefit.

Inventory system

Again, little information is available on this system because it has not yet been implemented by most libraries. It is clear, however, that the system can save money in finding materials reputed to be lost. Smart reports[17] on one library that found 500 lost items, for a savings of about $40,000 in replacement costs. Finding requested items, as noted above, is another benefit, although it is a bit harder to quantify.

Other benefits in quality/service

Reported benefits such as reducing lines at the circulation desk, patron satisfaction and staff satisfaction are best treated as quality improvements, and can be as important to a library as cost

savings. These need to be included in any cost/benefit analysis even though they cannot be easily quantified.

Doing a Cost-Benefits Analysis

In order to do a cost-benefits analysis for RFID, cost information will have to be gathered, future costs and assumed benefits realized will need to be projected. This will involve a fair amount of guess work. Because a fixed asset – equipment – is involved, the time period in which to project costs and benefits needs to be extended over the presumed life of the equipment. This in itself is problematic because RFID equipment has not been around very long, and its useful life is not yet known. For the purposes of this analysis, the period is assumed to be 10 years.

Below is an outline that describes which factors might reasonably be considered in determining costs and benefits related to RFID. The value of the benefits, when quantitative, are used to offset costs. Quality benefits cannot be directly subtracted from cost for obvious reasons.

Explanation of how to calculate each item follows the outline.

Costs and Benefits Outline

ONE TIME COSTS

I. Tagging/ conversion
    a. Supplies-cost of tags, cover labels, AV boxes (some systems), etc.
    b. Staff costs and any additional temporary staff

II. Equipment costs

III. Other-installation, training, pre-implementation research costs

ONE TIME BENEFITS

I. Weeding, inventory collection, collection development, finding missing items

ON-GOING COSTS

I. Tagging/Processing New Items
    a. Supplies-cost of tags, cover labels AV boxes
    b. *Subtract* supply costs from previous system (eg. EM systems-tattle tape, lock boxes, etc)
    c. Labor for processing
    d. *Subtract* labor for processing with previous system

II. Equipment-Maintenance
    a. Cost of maintenance contract
    b. *Subtract* cost of maintenance contract on current equipment.

ON-GOING BENEFITS

I Circulation staffing costs reduction, increase in service/productivity

II Savings on materials

III Savings due to reliability of equipment or less frequent replacement.

IV Quality improvements

One-Time Costs

I Tagging/Conversion

A. Supplies. Figure the cost of the tags and other supplies based either upon averages presented here, or upon costs gathered from likely vendors. Multiply per number of items to be tagged.

B. Labor. Decide who will do the tagging. Most libraries found it necessary to use their own staff either solely or in combination with volunteers and/or temporary paid personnel. Decide on whether you will count the cost of regularly scheduled staff in the calculation. If you decide to count staff labor as an implementation cost, you could estimate costs by taking the average hourly salary for those who will be tagging, and multiply it by the number of hours you estimate it will take to tag your collection. Count any additional labor costs from temporary personnel. Note that average time to tag one item was found to be 1 minute, with AV items taking longer. This should be taken only as a very rough guide. In general, libraries remarked that it took longer than they first imagined to tag the collection.

II Equipment costs

Estimate the cost of equipment based upon average costs, or upon costs gathered from likely vendors. Amount of equipment will vary based upon your goals, size of collection, size of staff, and so forth. Equipment costs should be amortized over the assumed life of the equipment. For this study the time suggested is 10 years for the "life of the equipment," but there is no real data to support what period is appropriate for RFID equipment, nor have the systems been around long enough to suggest the appropriate longevity period.

III Other costs

Installation costs are typically tied to how much equipment is to be installed. You can consult with likely vendors to get an estimated cost. The study data, though limited, suggests that these costs will probably be modest. Training costs for patrons and staff also should be included. Again, data suggests that the systems are easy to learn, making training costs quite modest. Some libraries included the cost of researching the technology and putting together their RFP. You may chose to include these pre-implementation costs or not.

One-Time Benefits

These benefits include the opportunity to weed, inventory the collection, do collection development and find missing or misshelved items. In general these can be regarded as quality improvements, however, there may be cost savings when missing or misshelved items are found and so do not need to be replaced.

ON-GOING COSTS

I Tagging/Processing New Items

A. Supplies. Cost of each tag subsequent to the initial purchase seems to be about the same as the originally quoted tag price. It is possible that tags will get cheaper over time; that has been the trend so far, as use of RFID systems increase. Multiply cost of tags and other supplies by the estimated number of new items to be tagged that are added to your collection every year. This should be figured each year for the period established for the life of the equipment.

B. *Subtract s*upply costs associated with your previous system. If you currently have a system such as an Electromagnetic security system, figure the cost of the supplies used in association with

your existing system (tattle tape, lock boxes, etc). Multiply by the number of new items added to the collection each year over the life of the RFID equipment. Subtract this number (costs you will no longer have to expend) from the cost of RFID processing to get the real cost of processing items.

C. Labor for processing. Three of the four libraries who reported on the time to process new materials with RFID reported that it took longer than their previous processing time. Figure the current per item time it takes to process an item, and add in at least an extra minute. Based upon the salaries of processing staff, and the number of items processed, you can estimate a labor cost for processing new items with RFID tags. Be sure to include an inflation factor as this cost should be figured yearly over each year of the life of the equipment.

D. *Subtract* Labor for processing with previous system. Based upon current processing time, number of items added to the collection per year, and staff salaries, compute the current cost of processing for each year over the life of the equipment.

Note: A simpler calculation would be to use some factor which reflects the additional time, from 1 minute to several minutes that it will take to tag, and multiply it by the number of items added per year. Figure the number of hours and multiply that by the average processing staff cost to get processing cost attributable to RFID. Figure that cost each year over the life of the equipment.

II Equipment Maintenance

A. Cost of maintenance contract. Ask vendors for an estimated cost (or what percentage of the contract for equipment) for yearly equipment maintenance. Figure this over the life of the equipment. Be sure to add in some factor for inflation over the period.

B. *Subtract* cost of maintenance contract on current equipment, if any, over the life of the RFID equipment, since this is money you will not be spending on the existing equipment.

On-Going Costs

I Circulation staff costs reduction/ increase in service/productivity

Consider what kinds of staff changes are possible given your goals for self check, and automated return. Consider whether your circulation is projected to rise (particularly if you are moving into a larger facility) and what productivity gains you might expect – which equates to money not spent on more staff to handle the increased load. Even without self-check, the quickness of staff-assisted check-out may result in savings. Staff check-in as well should be faster. If you are purchasing a sorting machine, you will need to project how this will affect sorting and shelving staff. Staff savings need to be projected over the established life of the equipment period. Be sure to include costs of benefits and an inflation factor over those years.

II Savings on Materials.

Theft Prevention/Missing Materials.

Savings are most likely on materials not stolen if you currently do not own a security system. The magnitude of this savings is difficult to predict unless you have some loss-rate statistics. If you already have a security system, it is even more difficult to predict whether cost savings are likely since the reliability and accuracy of RFID versus EM security is unknown. If you calculate savings in this area, they also should be projected every year over the life of the equipment.

Returning items to the shelf more quickly/finding requested items

If items are returned to the shelf more quickly, the library may save money on duplicate titles, or on transit costs of requesting items from other sites or other libraries. Staff time in looking for misplaced and misshelved can be saved as well. Be sure to project this each year over the period of the life of the equipment.

III Savings due to reliability of equipment or less frequent replacement.

In the end, reliability and longevity of the equipment can only be established over a longer period of time than systems have currently been in service. If there is increased reliability and longevity, this can translate to savings.

IV Quality improvements

These improvements should be listed as part of the whole picture of benefits realized but they are extremely difficult to quantify. Yet, as indicated, for a service organization such as a library, they may be very important when considering the expected value of RFID. Patron satisfaction, staff satisfaction, reduced lines at the check-out counter, quicker turn around time for returned and requested materials all may be experienced.

Spreadsheet Of Costs And Benefits

Included as Appendix 4 is a spreadsheet with headings for the items described above.

Suggested Data To Collect For Cost/Beneftis Analysis

For libraries considering RFID, what information is it useful to gather?

Circulation/staff statistics

- Current staffing levels of circulation staff, both base and peak levels, perhaps easiest to figure per hour
- Average per hour cost of circulation staff. Be sure to include cost of benefits (which can be substantial)
- Annual circulation statistics
- Number of open hours per year so per hour circ and per circ cost can be figured.
- Projection over the next 10 years (or period of life of the equipment) for circulation staffing. Remember that the greater amount of patron self-serve the more likely there will be staff savings/efficiencies at the circulation desk.
- Future projection for average per hour cost of circulation staff over the life of the equipment. Try to figure in something for inflation.
- Future circulation over the life of the equipment. Particularly if you are moving into a new or larger facility, you may see large jumps in circulation.
- Future number of hours per year you will be open over the life of the equipment. Guess!
- Current turnaround time from book return to placing on shelf.
- Cost of staff injuries over past several years, and future trend

- Average length of line at circulation desk during base and peak times.

Security/inventory

- Amount of time spent looking for lost, misplaced or items on hold
- Percentage of items presumed stolen, loss-rate
- Cost estimate of items presumed stolen

Processing materials

- Amount of time needed to process a new item
- Cost to process a new item, currently
- Projection on time and cost to process an item with RFID
- Number of items added per year

Equipment

- Current cost of maintenance on EM or other circulation/security equipment
- Reliability and effectiveness of current equipment (down time, service calls,etc)

Developments in RFID Systems

Let's look at some of the existing capabilities which not yet been fully implemented by many California libraries because of their newness. These aspects of RFID systems can affect the cost/benefits ratio once implemented.

AV solutions that provide security for materials, and do not require staff to open boxes to check materials. This can increase staff productivity in check in and check out, promote greater self-check and reduce theft. Some vendors are still developing their AV solutions and many libraries have not yet been able to confidently go to full self-check of AV materials either because of concerns about theft or difficulties in reading metallic AV materials. Systems that allow patrons to unlock the AV boxes at check-out promise to help minimize theft and increase self-check.

Inventory systems will aid in finding materials that are listed as "on the shelf," but are not found, items that are misshelved, presumed missing, claimed returned, or being collected for the hold shelf. Increases in staff productivity in finding materials more quickly, possible reduced cost in replacement of materials, and patron satisfaction could be expected.

Sorting systems promise to increase productivity of sorting/shelving staff by doing much of the check-in, rough and even fine sorting. The cost of these systems range from modest for a bin sorter to large for a fine-sort-to-book-cart system.

Patron self return can be implemented without a sorting system, by using the same type of machines used in check-in, or by technology at the book drop. Some systems provide receipts which can help reduce the number of items that are "claimed returned."

Fine Payment systems that allow patrons to pay fines at the self-check machines will reduce the number of patrons needing staff intervention at check out. This adds to the "one-stop shopping" approach that many patrons find convenient.

Pretagging of new items by book vendors will increase cost for libraries, but will decrease labor.

In a more general sense, the longer the track record, the more the capabilities and impacts – both negative and positive – will be known. Once libraries become more familiar with the technology through use and word of mouth, they will better understand what the systems actually can deliver. Initially, with new technology, users tend to be cautious implementers. If the initial experience is positive for library and patrons, libraries are likely to more fully utilize the technology's capacities, which can affect the cost/benefit relationship.

The future is certainly difficult to predict. If it follows a somewhat typical trajectory of technology development, we will probably see more standardization of the product as various features prove their value, and others fail to do so. This will make it easier for libraries to understand and compare the systems of the various vendors. However, with increased standardization, there may be increased ability to read tags from any vendor. This will, no doubt, increase concern about privacy and the security of the information on the tag. The need to encrypt the tag data or protect it in a more sophisticated manner will become more urgent. If the mode of placing and securing data on the tag itself is changed, where will that leave libraries that have the earlier version? Can the changes be made through the software? Certainly the industry will have to make sure that there is some way to update existing systems without replacing tags.

RFID systems will not be viable if periodic replacement of tags is necessary. The cost and effort associated with such an undertaking are too great.

---

[1] Jonathan Collins, "RFID's ROI Tops User Concerns." *RFID Journal.* (October, 2004) Available http://www.rfidjournal.com/articleview/1207/1/1

[2] Norman Oder. "A Day in the Life of International Libraries: Ambitious Meets Audacious." *Library Journal.* (February 1, 2004) Available http://www.libraryjournal.com/article/CA374952.html. Also, "Turning Up the RFID Ante in Public Libraries" www.itsc.org/synthesie/2002/library.pdf

[3] "Turning Up the RFID Ante in Public Libraries." *Synthesis Journal.* (October, 2002) pp. 15-20. Available http://www.itsc.org/synthesis/2002/library.pdf

[4] Glen E. Holt, Jens Ingemann Larsen, Ton van Vlimmeren."Customer self service in the hybrid library." Bertelsmann Foundation, (2002) pp 39-40. Available: http://www.public-libraries.net/html/customer_orientation.html

[5] Ibid, p40 Tags are read as they are returned in a book drop or book slide, at the Singapore Libraries.

[6] Ibid, p 30. A user survey from Denmark reports that "Most patrons also prefer self service for privacy reasons." This is not a comment on RFID tags, but seems rather to be that patrons can check out what they like without staff having to see their selections.

[7] Laura Smart. "Making Sense of RFID." *Library Journal* (October 15, 2004) p 2-3, Skokie Public Library (Illinois), notes that tags have been removed by patrons. "We find them in the rest rooms and lying on the shelves. It is not easy to remove them." Available: http://www.libraryjournal.com/index.asp?layout=articlePrint&articleID=CA456770

[8] Richard W. Boss. "RFID Technology for Libraries." *ALA Tech Notes* (February 2, 2006) p .6. Boss notes that he "found no evidence of removal (of tags) in the libraries he visited, nor did any of the library administrators contacted by telephone report a problem." Available: http://www.ala.org/ala/pla/plapubs/technotes/RFIDtechnoteupdate.doc

[9] Ibid, p 3. Libraries contacted by Boss reported a "50 to 75 percent reduction in false alarms with RFID" in comparison to EM systems http://www.ala.org/ala/pla/plapubs/technotes/RFIDtechnoteupdate.doc

[10] Ibid, p6.

[11] Laura Smart. p. 3 "This degradation may not be apparent when there are only one or two tags in the field, but when you have five or more, the drop in detection is considerable, to the 70 percent range."

[12] Richard W. Boss. p.3. Boss reports that "anecdotal evidence suggests that (detection rate is almost 100 percent)…whenever a reader is within 12 to 14 inches of tags, but there appears to be no statistical data to support the claims."

[13] Ibid., p 2 Boss notes that "there can be as much as a 50 percent increase in throughput. The time savings are less for charging than discharging because the time required for charging usually is extended by social interaction with patrons."

[14] Ibid., p.6 "The author knows of no library that has done a before and after inventory to determine the loss rate when RFID is used for security

[15] Stanley E. Hilliard and Kenneth D Kotnour. 3M Library Materials Loss Worksheet. Available: http://cms.3m.com/cms/CA/en/2-76/ckiFFFO/viewimage.jhtml

[16] Laura Smart, p.2

[17] Ibid., p.1

Appendices

Appendix 1: Libraries Included in the Study

Library	Circulation	Collection	Public/ Academic	Situation	Date	Vendor
Alhambra Public Library, Alhambra	510,000	158,000	P	existing	Complete 2001	Checkpoint
Berkeley Public Library, Berkeley	1,621,000	550,000	P	existing	Mostly complete June 2005	Checkpoint
California State University, Long Beach	250,000	1,400,000 tagged only 50,000	A	existing	Complete 1999	3M
Carlsbad City Library, Carlsbad	1,353,000	350,000	P	existing	Implement 2006	Vernon/ITG
Cerritos Public Library, Cerritos	1,112,000	245,000	P	new	Complete 2002	Checkpoint
El Dorado County Library, Placerville	743,000 entire system	30,000 one site only	P	new	Implement 2006	Tech Logic
Fresno County Library, Fresno	2,991,100 entire system	135,000 at two branches	P	one new, one existing	Complete Nov 2005, and March 2006	Tech Logic
Fullerton College, Fullerton	40,000	103,000	A	new	Complete Oct 2005	Checkpoint
Hartnell College, Salinas	40,000	60,000	A	new	Implement 2006	Checkpoint
Holy Names University, Oakland	3,000	112,000 tag 50,000 for now	A	existing	Implement 2006	Dynix/ TagSys

Library	Circulation	Collection	Public/ Academic	Situation	Date	Vendor
Long Beach Public Library, Long Beach	1,474,000	992,000 for all sites, 120,000 at two sites	P	existing	June 2005 one site, Jan 2006 second site	Tech Logic
Los Angeles Public Library, Los Angeles	15,744,000	25,000 for AV at one site	P	renovation of AV dept.	Complete 2002	Checkpoint
Madera Center Library, Madera	3,013	3,500	A	renovation	Complete August 2005	Checkpoint
Mira Costa College, Oceanside and San Elijo	64,900, both sites	55, 000 one site, 22,000 second site	A	new and existing	Complete 2004 one site, Implement 2007 (?) second site	Checkpoint
Monterey County Free Libraries, Salinas	46,500 one branch	17,800	P	existing	Complete 2002; future 12 branches	Checkpoint
Napa City-County Library, Napa	68,800 one branch	20,800one branch	P	new	Complete 2001	Checkpoint
Oakland Public Library, Oakland	53,800 one branch	65,000 one branch	P	new	Complete 2004	Libramation
Ontario City Library, Ontario	141,300	233,000	P	new and existing	Implement Jan 2006	Dynix/Tech Logic
Orange Public Library, Orange	664,500	258,000 tagging 163,000 at one site	P	new	Implement 2006	Vernon/ITG
Oxnard Public Library, Oxnard	178,000 one branch	80,000 at one site	P	new	Implement 2006	Bibliotheca

Library	Circulation	Collection	Public/ Academic	Situation	Date	Vendor
San Mateo Public Library, San Mateo	220,000 at two sites	305,000 at three sites	P	new and existing	Complete 2004 2 sites, Implement 2006 one site	Tech Logic
Santa Clara City Library, Santa Clara	2,630,000	390,000	P	new and existing	Complete 2000 /2004	Checkpt/Tech Logic
Santiago Canyon College, Orange	25,335	50,000	A	new	Implement 2006	Checkpoint
University of California, Merced	Not open yet one year	65,000	A	new	Implement 2006	Checkpoint

Appendix 2: Surveys

Two different surveys were sent to participants. The first ("Participant Survey") identified libraries that had implemented or were implementing RFID and asked some general information about the library. The second survey covered goals, costs, and benefits. Libraries completed the portions of the second survey based on how far along they were in their implementation and what data they had related to costs and benefits. We aspired to gather data on goals from all participants and on benefits from those with sufficient experience with the technology.

Survey 1: RFID Survey Participants Form

RFID Survey Participants Form

Thank you for agreeing to provide information on your RFID implementation. Your participation will help other California libraries make decisions about RFID in their libraries.

Contact person for survey:

Name	
Address	
E-mail	
Phone	

The Library

Library name	
Size of collection	
Number of branches	
Was RFID installed in…	___ a new library? ___ a renovation? ___ an existing library?
Annual circulation	for year:

Note: if RFID systems were installed at some branches and not others, those details will be explored in the phone interview. In this section, provide information for the library as a whole, to the extent possible.

RFID System

Name of RFID vendor	
Date of system purchase	
Date of implementation	

RFID Equipment and Supplies Costs

	$ cost	number purchased
Cost per book tag		
Cost per AV tag		
Cost per cover label		
AV container costs		
Security gates		
Staff check-in/out stations		
Self-check stations		
Portable scanners		
Programming stations		
Sorting equipment		
Other _____		
Other _____		

Survey 2: Costs, Goals and Benefits Survey

RFID QUESTIONNAIRE
Part 1 -- GOALS

Goal	**Primary goal**	**Secondary goal**	**Not a goal**
Patron self-check-out (give %)			
Reduce lines at circ desk			
Reduction in circ desk staff costs			
Patron self-return (give %)			
Return items to shelf more quickly			
Reduce staff injuries			
Increase security/reduce theft			
Increased equipment reliability			
Better inventory control			
Faster processing of new materials			
Track in-library use of materials			
Track materials more accurately			
Reduce costs for processing new materials			
Reduction of overall library staff costs			
Other _____			
Other _____			

Of these goals, which was the single most important goal that motivated your library to move to RFID?

RFID QUESTIONNAIRE
Part 2 -- Installation and Conversion

Cost to tag collection (either or both):

Time per item (min.) _____

Number of items tagged _____

Total cost in time (hours) _____

Total cost in dollars _____

Duration of tagging effort _____

Other significant staff costs (training, etc.)

In time (hours) _____

In dollars _____

Other labor costs

In time (hours) _____

In dollars _____

Vendor installation costs:

In dollars _____

BENEFITS Realized During Conversion

____ Shelf reading of entire collection

____ Inventory of collection

____ Weeding of collection

____

____

Of these benefits which one was the most valuable to you?

RFID QUESTIONNAIRE
Part 3 -- Ongoing Cost Comparison

Previous system (vendor and type) _____

Cost of supplies, processing (per item)

Number of new items added to collection per year _____

	RFID System	**Previous System**
Tags (books)		
Tags (other materials)		
Cover labels		
Barcodes		
Magnetic strips		
AV materials cases/locks		
Other supplies		

Time to process a new item

	RFID System	**Previous System**
Book		
AV material		
Other: _____		

Labor for circulating materials (per item)

	RFID System	Previous System
Time to check out an item at circ desk		
Time to check-in an item at return		
FTE circulation staff total or per hour: Base Peak times		
FTE check-in staff total or per hour: Base Peak times		
FTE shelving staff total or per hour: Base Peak times		
Percentage of materials self checked		
Percentage of materials self returned		

Cost comparison for maintenance of equipment (yearly)

	RFID System	Previous System
Maintenance costs		

Part 4 -- Benefits and Detriments

What benefits (or detriments) have you realized from your RFID implementation, such as:

Possible Benefit	**Major benefit**	**Minor benefit**	**Not realized/possible future benefit**	**Negative impact**
Patron self-check-out*				
Reduce lines at circ desk				
Reduction in circ desk staff costs				
Patron self-return				
Return items to shelf more quickly				
Reduce staff injuries				
Increase security/reduce theft				
Increased equipment reliability				
Better inventory control				
Better service for requested items				
Faster processing of new materials				
Reduce costs for processing new materials				
Tracking of in-library use of materials				
Reduction of overall library staff costs				
Patron satisfaction				
Staff satisfaction				
Other _____				
Other _____				
Other _____				

*

- Self check goal: ____ %
- Self check rate realized to date: ____ %

Anticipated future changes

Do you have plans to make more or new uses of RFID in the future?

Do you anticipate changes in staffing when your self-check goal is reached?

Other comments and observations

What other comments or observations do you have about the changes brought by RFID?

Did the introduction of RFID cause the library to make changes in policy (e.g. limits on checkouts, privacy policy, self-service holds)? Have those changes had any implications for staffing or other costs?

Are there other time, staff, cost, service or satisfaction implications you have seen which have not been covered above?

Appendix 3: Results

Goals – All Libraries

Goal	Primary goal	Secondary goal	Not a goal
Patron self-check-out	13	3	2
Reduce lines at circ desk	9	7	
Reduction in circ desk staff costs	8	6	1
Patron self-return	3	3	9
Return items to shelf more quickly	5	9	1
Reduce staff injuries	8	7	2
Increase security/reduce theft	13	4	1
Increased equipment reliability	2	7	6
Better inventory control	11	7	
Faster processing of new materials	4	3	8
Track in-library use of materials	5	4	7
Track materials more accurately	8	4	4
Reduce costs for processing new materials	1	3	11
Reduction (or maintain)of overall library staff costs	8	4	4
Other ____Efficiency/redeploy staff_____	3		
Other __Good service_____	1		
Other Locate missing items		1	
Other Interface with future technology	1		

Goals – Public Libraries

Goal	Primary goal	Secondary goal	Not a goal
Patron self-check-out	10	1	
Reduce lines at circ desk	7	3	
Reduction in circ desk staff costs	6	4	
Patron self-return	3	2	4
Return items to shelf more quickly	5	4	1
Reduce staff injuries	6	5	
Increase security/reduce theft	7	3	1
Increased equipment reliability	1	3	5
Better inventory control	5	6	
Faster processing of new materials	1	2	7
Track in-library use of materials	2	2	5
Track materials more accurately	5	3	2
Reduce costs for processing new materials	1	1	8
Reduction of overall library staff costs	7	1	3
Other ____Efficiency/redeploy staff_____	3		
Other __Good service_____	1		
Other Locate missing items		1	
Other Interface with future technology	1		

Goals – Academic Libraries

Goal	Primary goal	Secondary goal	Not a goal
Patron self-check-out	3	2	2
Reduce lines at circ desk	2	4	
Reduction in circ desk staff costs	2	2	1
Patron self-return		1	5
Return items to shelf more quickly		5	
Reduce staff injuries	2	2	2
Increase security/reduce theft	6	1	
Increased equipment reliability	1	4	1
Better inventory control	6	1	
Faster processing of new materials	3	1	1
Track in-library use of materials	3	2	2
Track materials more accurately	3	1	2
Reduce costs for processing new materials		2	3
Reduction (or maintain)of overall library staff costs	1	3	1
Other ____Efficiency/redeploy staff_____		1	
Other __Good service_____			
Other Locate missing items			
Other Interface with future technology			

Benefits and Detriments

What benefits (or detriments) have you realized from your RFID implementation? Check all that apply.

Possible Benefit	**Major benefit**	**Minor benefit**	**Possible future benefit**	**Negative impact**
Patron self-check-out (*see below)	5	3	1	
Reduce lines at circ desk	4	2	4	
Reduction in circ desk staff costs	3		6	
Patron self-return		1	6	
Return items to shelf more quickly	3	1	4	
Reduce staff injuries	1	3	5	
Increase security/reduce theft	2	3	4	1
Increased equipment reliability	4	1	2	
Better inventory control	3		6	
Better service for requested items	3	1	4	
Faster processing of new materials	2	2	5	1
Reduce costs for processing new materials		2	5	2
Tracking of in-library use of materials		2	6	
Reduction of overall library staff costs	2	1	5	
Patron satisfaction	5	2	3	
Staff satisfaction	2	5	3	

Appendix 4: Spreadsheet

Costs

	year 1 only
One time supplies	
Tags	
Cover labels	
AV tags	
AV boxes (some systems only)	

One time labor costs for tagging	
Regular staff (if included)	
"Additional, paid personnel "	
Training staff or patrons	
One-time Equipment Installation	

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	cumulative
Equipment costs											
Equipment (divide cost over life of equipment)											

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	cumulative
On going maint costs											
Maint contract (over life of equipment)											
Subtract cost of maint on previous equip	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
On going supplies for new materials											
Tags											
Cover labels											
AV tags											
AV boxes											
Subtract previous system on going cost of supplies											
Tattle tape	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
AV tattle tape	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	cumulative
"Lock boxes, etc (some systems only)"	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
On going labor costs for processing											
Cost of staff time per item times no. of items											
Subtract previous system on going labor costs for processing											
Previous cost of staff time per item times no. of items	( )	( )	( )	( )	( )	( )	( )	( )	( )	( )	
Subtotal costs											

Benefits

	year 1	year 2	year 3	year 4	year 5	year 6	year 7	year 8	year 9	year 10	cumulative
On going benefits/savings											
staff cost savings (over life of equipment)											
increased service, same staff levels (over life of" equipment)											
Savings on materials costs											
Savings on materials kept through theft prevention											
"Cost of items found, not needing replacement"											
Savings not buying duplicate materials											
Subtotal benefits											
TOTAL (benefits-costs)											

Non-cost benefits-one time	
Weeding whole collection	
Collection development information	

	year 1	**year 2**	**year 3**	**year 4**	**year 5**	**year 6**	**year 7**	**year 8**	**year 9**	**year 10**
Non-cost benefits-on going										
Shorter lines at circulation desk										
Quicker turn around time on reshelving returns										
Patron satisfaction										
Staff satisfaction										
Better service										
Others										

Bibliography

Libraries and RFID

Ayre, Laurie B. RFID and Libraries. (August 19, 2004) Available: http://www.galecia.com/weblog/mt/archives/cat_rfidandwireless.php

Berkeley Public Library. Best Practices for RFID technology. (2004) Available: http://berkeleypubliclibrary.org/BESTPRAC.pdf

Boss, Richard. "Library RFID technology." *Library Technology Reports* (Nov/Dec 2003) 58 p.

Boss, Richard W. "RFID technology for libraries." *ALA Tech Notes*. (May 14, 2004) Available: http://www.ala.org/PrinterTemplate.cfm?Section=technotes&Template=/ContentManagement/HTMLDisplay.cfm&ContentID=68138

Campbell, Anita. RFID Weblog.. Available: http://www.rfid-weblog.com/

Carlson, S. "Talking tags: new high-tech labels help libraries track books, but worry privacy advocates." *The Chronicle of Higher Education* (August 6, 2004) Available: http://chronicle.com/free/v50/i48/48a02901.htm

Chachra, Vinod. Experiences in implementing the VTLS RFID solution in a multi-vendor environment. Presentation at 69th IFLA General Conference and Council, 2003.. Available: http://www.ifla.org/IV/ifla69/papers/132e-Chachra.pdf

"Conference Call Should Libraries Play Tag with RFIDs?" *American Libraries* (December, 2003.) pp. 69-71.

Coyle, Karen. "Management of RFID in Libraries." *The Journal of Academic Librarianship*, 31, (September 2005): 486-489

Fabbi, Jennifer L, Sidney D. Watson, Kenneth E. Marks. "Implementation of the 3M™ Digital Identification System at the UNLV libraries." *Library Hi Tech* 20 (March 2002): 104 – 110

Holt, Glen E., Jens Ingemann Larsen, Ton van Vlimmeren. Customer self service in the hybrid library. Bertelsmann Foundation, (2002) pp 39-40. Available: http://www.public-libraries.net/html/customer_orientation.html

Kern, Christian. "Radio-frequency-identification for security and media circulation in libraries." *The Electronic Library*. 22 (August 2004): 317-324

Lindquist, M. G.. RFID in libraries – introduction to the issues. Presentation at 69th IFLA General Conference and Council, 2003..August, 2003. Available: http://www.ifla.org/IV/ifla69/papers/161e-Lindquist.pdf

McArthur, A. Integrating RFID into library systems – Myths and realities. Presentation at 69th IFLA General Conference and Council, 2003..August, 2003. Available: http://www.ifla.org/IV/ifla69/papers/130e-McArthur.pdf

Murray, P.E.. The Radio Frequency Revolution: Tips and Trends for Implementing RFID Systems in Libraries – University of Connecticut's Implementation. (January 28, 2004) Available: http://www.pandc.org/peter/presentations/ala-2004-rfid/

Oder, Norman. "A Day in the Life of International Libraries: Ambitious Meets Audacious." *Library Journal*. (February 1, 2004) Available: http://www.libraryjournal.com/article/CA374952.html.

"Overview of library RFID products." *Libramation* (2004) Available: http://www.libramation.com/prod_radio.html

"Radio-tagged books: Why librarians should switch on their books." *Research Information.* (May/June, 2004) Available: http://www.researchinformation.info/rimayjun04radiotagged.html

Santa Clara City Library.. Checkpoint RFID and the Santa Clara City Library. January, 2004. Available: http://www.library.ci.santa-clara.ca.us/rfid/checkpoint.html

Schneider, Karen. RFID and libraries: Both sides of the chip. (November 19, 2003) Available: http://www.senate.ca.gov/ftp/SEN/COMMITTEE/STANDING/ENERGY/_home/11-20-03karen.pdf

Schuyler, M.. RFID: "Helpmate or conspiracy?" *Computers in Libraries* (January, 2004) pp. 22 – 24

Smart, Laura. "Making Sense of RFID." *NetConnect* (Oct. 15, 2004) pp. 4-14.

"Turning Up the RFID Ante in Public Libraries." *Synthesis Journal.* (October, 2002) pp. 15-20. Available: http://www.itsc.org/synthesis/2002/library.pdf

Ward, D. M.. "RFID Systems." *Computers in Libraries*, March, 2004 19 – 24.

RFID Technology

Collins, Jonathan. "RFID's ROI Tops User Concerns." *RFID Journal.* (October, 2004) Available: http://www.rfidjournal.com/articleview/1207/1/1

EPC Global. Guidelines on EPC for Consumer Products... Available: http://www.epcglobalinc.org/public_policy/public_policy_guidelines.html

Federal Trade Commission. RFID Radio Frequency Identification: Applications and Implications for Consumers. Washington, D.C., FTC, (March, 2005)

Mayfield, K. Radio ID Tags: Beyond Bar Codes. Wired News (May 20, 2002) Available: http://www.wired.com/news/technology/0,1282,52343,00.html

PeopleSoft. Improving Performance with Radio Frequency Identification (RFID).PeopleSoft What Paper Series. Pleasanton, CA. (April, 2004)

Want, Roy. "RFID, a Key to Automating Everything." *Scientific American* (January, 2004) pp. 57-64.

RFID and Privacy

AIM, Inc. RFID connections - ROI of privacy invasion. Available: http://www.aimglobal.org/technologies/rfid/resources/articles/jan04/0401-roispy.htm

American Library Association. Code of Ethics of American Library Association Available: http://www.ala.org/ala/oif/statementspols/codeofethis/codethics.htm

Artz, M. "City library adopts controversial RFID Chips." *Berkeley Daily Planet.* (October 10, 2003.) Available: http://www.berkeleydailyplanet.com/article.cfm?archiveDate=10-10-03&storyID=17547

Chachra, Vinod and Daniel McPherson. Personal privacy and use of RFID technology in libraries. VTLS. October 31, 2003. 7 p.. Available: http://www/vtls.com/documents/privacy.pdf

Consumers against Supermarket Privacy Invasion and Numbering (CASPIAN). Position statement on the use of RFID on consumer products. Position statement on the use of RFID on consumer products. Available: http://www.privacyrights.org/ar/RFIDposition.htm

Garfinkel, Simson and Beth Rosenberg. *RFID : Applications, Security, and Privacy.* Addison Wesley, 2005

Givens, Beth. RFID implementation in libraries: Some recommendations for "Best Practices. .Summary of presentation to the ALA Intellectual Freedom Committee of the American Library Association at the ALA

Mid-Winter Conference, San Diego, California. January 10, 2003. Available: http://www.privacyrights.org/ar/RFID-ALA.htm

Good, Nathan et al.. Radio Frequency Id and Privacy with Information Goods. Paper given at the Workshop On Privacy In The Electronic Society. Washington, D.C., October 28, 2004. Washington, D.C. Association for Computing Machinery.

Molnar, David and David Wagner. Privacy and Security in Library RFID: Issues, Practices, and Architectures. Paper presented at CCS'04, October 25-29, 2004, Washington D.C. Assocation of Computing Machinery (2004) pp. 210-219.

Molnar, David, and Wagner, D.A.. Privacy and security in library RFID: Issues, practices and architectures (June 8, 2004) Available: http://www.cs.berkeley.edu/~dmolnar/library.pdf

Tien, Lee. Privacy risks of radio frequency identification "tagging" of library books. Electronic Frontier Foundation, October, 2003. Available: http://www.eff.org/Privacy/Surveillance/RFID/20031002_sfpl_comments.php

Tien, Lee. RFID and libraries: EFF talking points for the ALA IFC. Summary of presentation to the ALA Intellectual Freedom Committee of the American Library Association ALA Mid-Winter Conference, San Diego, California. January 10, 2004. Available: http://www.privacyrights.org/ar/RFID-ALA.htm

Warfield, Peter and Lee Tien. RFID: "Many Problems, Little Public Discussion." *Berkeley Daily Planet* (April 8, 2005) Available: http://www.berkeleydailyplanet.com/article.cfm?archiveDate=04-08-05&storyID=21128

RFID, Electromagnetic Fields, and Health

California. Department of Health Services. California Electric and Magnetic Fields Program. Short Factsheet on EMF. Sacramento, Department of Health Services, 1999. 4p.

Federal Communications Commission. "Office of Engineering and Technology. Questions and Answers about Biological Effects and Potential Hazards of Radiofrequency Electromagnetic Fields." *OET Bulletin 56*, 4th Edition. Washington, D.C., FCC, August, 1999. 36 p..

International Commission on Non-Ionizing Radiation Protection. Possible Health Risks to the General Public from the Use of Security and Similar Devices: Executive Summary. Oberschleisheim, ICNIRP, 2002. 18p. ISBN 3-934994-02-4.

Pacific Gas and Electric Company. Understanding EMF: Electric and Magnetic Fields. PG&E, December, 2004.

World Health Organization. Electromagnetic Field Project.. Available: http://www.who.int/peh-emf/en/

World Health Organization. What Are Electromagnetic Fields?. Geneva, World Health Organization, n.d.. Available: http://www.who.int/peh-emf/about/WhatisEMF/en/index.html