

MIT's DSpace Experience: A Case Study

Introduction

This paper exists to extract from MIT's DSpace history the parts of the experience that will assist other institutions in planning their individual implementations of DSpace.

It needs to be said at the outset that future implementers of DSpace ought not expect theirs to echo MIT's DSpace experience. Even though the development of the DSpace software necessarily preceded its implementation as a service, both development and implementation evolved in concert. The time used to write code helped MIT Libraries accomplish what was needed to introduce this major new service to and into the Institute. Because future implementers of DSpace will download the already developed and tested, open source DSpace software, the technical implementation of DSpace should require only local adjustments, if any; but, as MIT did, they will need to make time to plant the idea of DSpace, to allow it to take root, and then to nourish it.

DSpace itself introduces into both the institution and the library hosting DSpace new ways of thinking about well-ensconced workflows and policies. Faculty members, for example, must participate actively in making sure their research doesn't fall prey to the obsolescence of specific information technologies; they must actively seek the management help of DSpace, under whose stewardship the research will be brought forward as technologies do change or disappear. At the same time, collection managers increasingly need to be thinking of their work no longer, for example, at the level of journals and books only, but also at the level of individual articles or datasets. The introduction of DSpace, in other words, changes not only the way we think about the lifecycle of scholarly research, but also the operating definitions of units of the scholarly enterprise.

This document means to make useful to others MIT's particular experience introducing DSpace into the MIT Libraries' daily operations. It is our hope that it provides a tale that will help future implementers plan their course thoughtfully.

The birth of an idea

The idea to create a digital institutional repository¹ at MIT emerged in conversations the director of the MIT Libraries, Ann J. Wolpert, had with members of the Institute's faculty in 1997.² She began noticing a need: she quotes one faculty member as lamenting in a joking fashion that his "entire life's work is in [his] email." This message conspired with the shifting trends of electronic scholarly publishing as well as the community's increasing requests for on-demand document delivery to set Director Wolpert on the track that led to DSpace. Because university communities rely on their libraries to provide continued access to research and scholarship, Wolpert and Eric F. Celeste, then Assistant Director for Technology, Planning, and Administration at the MIT Libraries, positioned the Libraries to devise a solution to the problem of storing and retrieving MIT's intellectual work over the long term. Her on-going conversations with MIT computer scientist Hal Abelson eventually led to a meeting with Hewlett-Packard Labs, with whom the MIT Libraries signed a co-development contract in March 2000. Finally, it was MacKenzie Smith, who, as the Libraries' Associate Director for Technology since January 2001, helped drive the project to completion for the November 2002 launch.

¹ The MIT Libraries espouses SPARC's use of the term "institutional repository" to denote "digital collections capturing and preserving the intellectual output of a single university or a multiple institution community of colleges and universities."

(http://www.arl.org/sparc/IR/IR_Guide.html#repository).

² The DSpace project follows upon a series of research projects in digital library initiatives that emerged after the publication of Vannevar Bush's forward-thinking "As We May Think" in the July 1945 issue of The Atlantic Monthly. Of these, DSpace is the first to go into full production and service.

From the outset, the plan was to create an infrastructure for storing the digitally born, intellectual output of the MIT community and to make it accessible over the long term to the broadest possible readership. How might one store and manage the intellectual output of the MIT community so that it won't sink, forever lost, into the quicksand of software and hardware obsolescence?³

A Brief Chronology

The anticipated 12-month development schedule, set shortly after the Libraries' contract with HP Labs was signed, revealed itself to be optimistic. Hiring a team and defining the technical specifications⁴ took longer than expected. While the core staff came on board in the months immediately following the contract's signing, hiring continued well into the next year. From contract (March 2000) to launch (Nov. 2002), over two years elapsed.

The DSpace team recognized the value of the OAIS framework and recast the repository's architecture to accommodate this archival framework.⁵ Having made this decision in early 2001, the project quickly reached successive milestones. By the fall of 2001 a Libraries transition team was in place to determine the smoothest course for adding DSpace services to the MIT Libraries existing services. By July 2002, two business strategists had accomplished their year-long assessment of how to sustain DSpace into the future financially. In the meantime, DSpace's early adopters came on board in March 2002 and worked with the DSpace team through September 2002, when their content became publicly available, to test the whole system and the processes that needed tweaking. DSpace was officially launched on the same date its source code was released under Open Source BSD license: November 4, 2002.

³ Others may want to consider using the DSpace infrastructure for other purposes (e.g. records administration and archiving, electronic theses, learning management systems, etc...)

⁴ The first technical specifications figured as a document affectionately called the DOSO.

⁵ For more on the Open Archival Information System, see

<http://www.rlg.org/longterm/oais.html>.

What is DSpace?

DSpace means different things to different people and constituencies. Sometimes it refers to technology--for DSpace is an application. DSpace followed the librarian's inclination to create a system that would be as easy as possible to implement and use, rather than push strictly in the direction of digital library research from which a more flexible system might have emerged. DSpace, therefore, was designed as an open source application that institutions and organizations could run with relatively few resources. The intention to support interoperability (with DSpace implementers at other institutions, for example) led to the adoption of the Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH);⁶ The OAI Registry includes DSpace, making its Dublin-Core-formatted metadata available to compatible harvesting code. In addition, DSpace chose to implement CNRI handles⁷ as the persistent identifier associated with each item to insure that the system will be able to locate and retrieve documents in the distant future. DSpace was also designed with a batch load submission feature to ease the loading of exiting collection and cut costs.

DSpace the technology, then, is the software—the open source computer application that drives and manages submission, storage, and retrieval processes. But DSpace has non-technological aspects of importance, which this narrative will highlight for the benefit of those who need no longer develop the application.

- **DSpace, the project.** Conceived in the late 1990s, the project took formal flight with the March 2000 signing of a contract between Hewlett-Packard Laboratories and the MIT Libraries.
- **DSpace, the program.** The longer-term DSpace research program.

⁶ Open Archives Initiative Protocol for Metadata Harvesting (OAI-PMH), <http://www.openarchives.org/OAI/openarchivesprotocol.htm>.

⁷ Information about the Handle System® is available at <http://www.handle.net>

- **DSpace, the service.** The access to the intellectual output of the MIT community, offered by the MIT Libraries to the MIT community and the world beyond it.
- **DSpace** is also, finally, the name of the name of MIT's institutional repository.

There are meanings of DSpace with which users will need to acquaint themselves: the set of services, the policies, the submission process, issues of access, and so on.

Offering DSpace services at MIT required:

- Planning and developing a set of services that reflect MIT and Libraries' policies;
- Financially sustaining the repository
- Managing and preserving the data so it remains retrievable
- Finding and working with early adopters
- Hiring staff
- Advocating and getting the word out
- Training the Libraries' staff and the DSpace communities
- Rolling the services out the MIT community and to the public at large.

For each of these activities, DSpace paid special attention to its major stakeholders and supporters, both regarding the impact the new services might have on each; and with respect to the role each might play in promoting, supporting, and, of course, using DSpace. The constituencies that DSpace kept in focus were:

- The MIT faculty, whose scholarship and research DSpace exists to usher into the future.
- The staff of the MIT libraries, which is responsible for deploying, running, and maintaining the DSpace system and services into the future.
- The MIT administration—long-term planners and decision-makers—in light of the Institution's intellectual and financial commitment to a project of the magnitude of DSpace.

- Members of the MIT community, whose intellectual and political influence focus attention and develop momentum in support of DSpace.
- The early adopters – and their eventual successors, the so-called fast followers.

Raising Awareness & Advocating

It will no doubt surprise anybody any longer that, in order to succeed, a project like DSpace must market itself and garner the support that matter to its survival; that support must come from key members of the community and spread organically, as it were, by word-of-mouth. Opinion leaders, key administrators, respected members of the faculty must be courted and persuaded; their conversation about the project will create buzz and their endorsement will promote credibility. At MIT, word-of-mouth, a most infectious means of disseminating excitement, continues to prove very effective.

Though informally excitement spreads like wild fire, the fire must be lit and stoked by planned, more formal interventions: the idea of DSpace must be made to capture the imagination of the faculty – and the implementation must offer the solution to problems some may not even have known they have. The DSpace team introduced DSpace to members of the MIT community both programmatically and informally. In addition to their individual, enthusiastic, everyday conversations, the team prepared presentations for small groups that expressed curiosity and created forums for discussion of what DSpace would be and how it would help the MIT community and its various parties. The Director presented to her colleagues on campus and helped solidify arrangements with early adopters. A free DSpace-Announce electronic mailing regularly reached subscribers, reporting on the project's news and progress. The Libraries' public relations office sent press releases about DSpace's milestones to the news media outside of MIT. Their pieces are collected at the [DSpace News and Related Readings page](http://libraries.mit.edu/dspace-fed-test/news/index.html) (<http://libraries.mit.edu/dspace-fed-test/news/index.html>). The word was getting out.

Garnering the support of key administrators was crucial: the DSpace horizon required their backing. Engaging the enthusiasm of the MIT's influential movers turned out to be contagious. Introducing the faculty to a notion some had doubtless never contemplated

was exciting. These activities took place concurrently and set in motion the process of finding financial resources.

The DSpace Team

To keep the project moving ahead some organizational changes took place. The project's team was also formalized: a project manager from HP Labs joined several engineers and MIT librarians. One of the librarians served as liaison to the faculty. The team also included two business strategists who helped in the process of moving the project into the daily operations of the Libraries in addition to recommending funding models for DSpace's long-term sustainability.

The Libraries' Director strategically invited specific faculty members to sit on the newly formed DSpace Faculty Advisory Board to help guide and support the project and its working team members. Their familiarity with the concept raised healthy discussion among their peers and continues to proffer invaluable advice as the project moves forward.

As word about DSpace circulated and the team took shape, a flood of questions began coming in. What content would DSpace house? How much of it could be submitted? Who would submit content? Could one remove a submission later? What about this digital format or that? It was time to attend to the many policy questions both the DSpace team and the DSpace buzz generated.

Devising Sound Policies

One of the most complex aspects of introducing an institutional repository into the varied set of library services is setting the policies. MIT's DSpace policy development process, which continues today and will continue into the future, reflects the complexity of the issues at hand. It also reveals the MIT community's constantly evolving awareness of DSpace's potential.

As suggested above, at every turn, the DSpace team faced policy questions. Cognizant of the wisdom that policies ought to shape software development and not the reverse (an often alluring option!), DSpace’s technical team often sought policy decisions before moving forward with their coding. There was no shortage of decisions to be made to move ahead with the software’s development. These policy decisions are one that future implementers will not have to make—decisions resulting, for example, trade-offs: a simpler implementation for a less flexible repository.

Some policy decisions, driven by the MIT community’s needs and culture, affected how the DSpace software and infrastructure can and will be used. Other policy decisions reflected the Institute’ and the Libraries’ missions and commitments—and will have to be shaped on an individual institutional basis. Philosophically, MIT followed a “reasonable request” principle in fashioning policies: while not being able to subsidize all requests, the goal was to remain, above all, very service-oriented. Others may want to approach designing policy quite differently. In the MIT experience, input from various parts of the MIT community influenced the fashioning of policy.

Among the early policy decisions the DSpace team discussed and settled on were those involving the scope and boundaries of the DSpace service the MIT Libraries would offer—in large measure to get better definition of what it was the team was creating. Most of these early policy decisions resulted from philosophical commitments and the Libraries’ mission—e.g. open source software, free access wherever possible to anyone browsing the web, etc.... As the project evolved, the need to create policy emerged from several corners of the MIT community. Feedback was a crucial conduit in making sure that DSpace would suit MIT’s culture. The Institute’s administrators and staff, the faculty, and the staff of the MIT Libraries variously contributed to this on-going feedback loop.

- Inquiring faculty members raised a great number of very important questions. Several faculty members, for example, asked about removing old versions of re-written articles, which prompted thinking through what might indeed be

withdrawn from DSpace, if anything at all, and under what circumstances. Two surveys were also delivered to the faculty, each with a dual purpose: to request the faculty's input and to inform it of what was afoot.

- The Libraries' administrators and staff, in the course of introducing the DSpace concept to the MIT community, helped the DSpace team understand what sorts of things needed to be explained in greater depth, what sorts of trainings needed to be planned, and how efforts had to be sustained.
- In meetings with non-DSpace-team Libraries' staff, the DSpace team learned more about what organizational changes would be needed to manage and maintain the DSpace service once it became part of the MIT Libraries services.

Drawing up policy can, of course, be difficult because it often affects many constituencies. Librarians typically want to maintain the scholarly record as put forth by their mission. Faculty members may hesitate to submit their research because the commitment is irreversible (except as demanded by law). Administrators may want to privilege cost-cutting policies wherever possible, sometimes running afoul of either operations or faculty needs. MIT's experience is that compromise is quite attainable—and makes the DSpace service all the stronger following careful, in-depth debate.

Setting policy also drives further work for the DSpace team and for the submitting communities. Here's one example. After a great deal of discussion, the DSpace team decided as a matter of policy that each community would be responsible to enter metadata for the items it deposits into DSpace. Establishing this policy meant that developers needed to create web interfaces to accept the submitter's input and code to commute the data into storable and manageable metadata packages. It also meant that submitters in each and every community would need to be trained to enter appropriate metadata so the system would recognize and know how to handle it. Recognizing that an easy-to-use submission process would eliminate barriers to faculty participation, the DSpace team's policy decision led to a minimum requirement for metadata consisting of only three fields. Requiring only three fields, but allowing many more, it is hoped, will

have the extra effect of lowering the barrier to entry for submitters with insufficient time on their hands to attend to the fuller process.

Some policies reflect current knowledge about available technologies and will need to be refined as technologies evolve and new ones replace existing ones. Owing to the varieties of formats used in by the MIT's faculty in its research, for example, the DSpace team realized it would have to accept research in many different digital formats. But because the means to preserve some of these formats are still under investigation by researchers in the field of digital preservation, the DSpace team could not promise to preserve all formats with equal success. To address these differences, the team devised several levels of service promise, which DSpace describes in greater detail in the [DSpace Functional Overview](http://libraries.mit.edu/dspace-fed-test/technology/function.html) (<http://libraries.mit.edu/dspace-fed-test/technology/function.html>).

The process of refining policies continues as new questions arise. Having expressed some disparate policies early on, for example, the DSpace team later created a policy statement for submitters, to assure that everyone understands the terms of the Libraries commitment and responsibilities as well as those of the submitting community. To monitor the quality of policies, to keep them current and in tune with MIT's culture, and to enforce them, the MIT Libraries created The DSpace@MIT Policy Committee, even as DSpace was rolled out to the public. This committee is charged “with ongoing responsibility for advising the Associate Director for Technology on all aspects of policy related to deployment of the DSpace system at MIT.” At any given time, DSpace current policies are readily available on the [Policy Planning](http://libraries.mit.edu/dspace-fed-test/implement/policy-planning.html) web page (<http://libraries.mit.edu/dspace-fed-test/implement/policy-planning.html>). To read them is to get a sense of the breadth and depth of what a DSpace implementation requires to assure that services be rolled out smoothly and legally.

The Sustainability Imperative

As the development of DSpace progressed and before it could actually be introduced into the broader set of MIT Libraries' services, the question of financial sustainability gnawed. It was one of the most persistently difficult questions and it emerged at the

outset: assuming this repository could indeed be built, how would the Libraries at MIT sustain it? Where would the monies come from to live up to the promise of data persistence and retrievability over the long haul?

The sustainability imperative became increasingly vexing, as it will at institutions in which administrations encourage independent funding or cost-recovery models to finance these sorts of initiatives. The Mellon Foundation granted the MIT Libraries' monies to add two business strategists⁸ to the DSpace team, whose charge it was to study the problem and devise a sustainable financial plan. Their work resulted in the July 2002 publication of MIT Libraries' DSpace Business Plan Project Report to the Andrew W. Mellon Foundation (<http://libraries.mit.edu/dspace-fed-test/implement/mellon.pdf>).

The importance of planning for the financial support of this sort of endeavor cannot be underestimated. In trying to identify funding sources, several overarching concerns surfaced:

- Topping the list is the open-ended, long-term nature of the project. What would it cost to run, support, maintain, and upgrade DSpace services over many decades?
- Capturing the costs of data preservation, specifically, remains one of the biggest unknown and least measurable items, in large part because research has yet to be undertaken on the feasibility and cost associated with large-sized data migrations.
- Although storage is not, generally speaking, the expensive proposition it used to be, storage must be taken far more seriously when one considers the size of some of the proposed deposits into DSpace. A recent inquiry came to the DSpace team regarding depositing a single, 30-terabyte dataset, for example. Managing the storage capacity for datasets of this size requires careful financial planning.⁹

⁸ Mary Barton and Julie Harford Walker joined the DSpace team in the spring of 2001.

⁹ Stephen Chapman analyzes the storage costs of long-term, digital preservation in "Counting the Costs of Digital Preservation: Is Repository Storage Affordable?" in Journal of Digital Information, volume 4 issue 2, <http://jodi.ecs.soton.ac.uk/Articles/v04/i02/Chapman/>.

- Forecasting staffing is also essential since it can quickly become a major expense.
- Finally, introducing DSpace into a library environment will drain already typically restricted funds. Whatever the cost models and financing plans, creative approaches will always be welcomed in tight economic times.

In working on their plan, the business strategists raised several possible configurations for the on-going funding of a service such as DSpace. They stayed attuned to the assumptions that the DSpace team was making—in the process, unearthing issues that would require further policy guidelines and attention.

The DSpace Set of Services

One of the business analysis' outcomes was that it helped define both the Core Services, which the Libraries would make available free of charge; and the Premium Services, for which the Libraries could charge fees. As DSpace grows, further attention will be paid to the Premium Services, which might include accommodating such extraordinary resource demands as extra storage space and customizing services for specialized needs. Premium Services will be introduced in a controlled fashion so as not to overtax the Libraries resources. In the meantime the DSpace team settled on a two-part Core Service to address a broad base of needs and offer basic support and functionality as soon as would be possible. At launch, the Core Service included:

- The **Managed Services**, which DSpace promises to the submitting communities on one hand, and to the community of end-users within the MIT community and in the web-browsing world at large, on the other hand. Broadly speaking, these comprise storage, management, retrieval, and differing levels of preservation (including the requisite back-up, recovery, and general systems monitoring and maintenance), as well as ongoing user support to communities, librarians, and end-users alike.
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- **End-user Services** designed for communities to perform the tasks that their submission and access processes require.

Services beyond these two broad Core Services fall into the category of Premium Services and will be offered on a fee-for-service basis. More information about current DSpace services offered at MIT can be obtained from the [MIT Libraries' DSpace Business Plan Project Report to the Andrew W. Mellon Foundation](http://libraries.mit.edu/dspace-fed-test/implement/mellon.pdf) (<http://libraries.mit.edu/dspace-fed-test/implement/mellon.pdf>).

DSpace services exist in concert with policies that sustain them; planning these services and setting policies supported and refracted each other. Creating a model for such a set of services turns out to be an iterative process that needs to begin in the early phases of project planning. The MIT DSpace services evolved throughout as the team learned more about the faculty's needs and the types of research materials faculty members produced. Some of the DSpace team's early expectations—that submissions, for example, would predominantly consist of text materials—were mistaken. The team learned directly from the faculty that it wanted DSpace to manage datasets, images, videos, and other types of communication vehicles, in a variety of digital formats. The DSpace service plan had to reflect that.

Overall, the set of DSpace services are—and continue to be—a balancing act. As the DSpace team acquired a better grasp of the magnitude of the system it needed to design and what it would take to maintain and support it, it established restrictions on content and other aspects of the service to make sure that the Libraries had the resources to deliver the service and manage the support. The MIT Libraries wanted to continue to provide free and robust services to users who are accustomed to no less—and often expect it all the more today from electronic environments.

DSpace's Early Adopters

Having already mentioned the importance of the community's role in shaping DSpace, it's important to note that the DSpace team formally and programmatically gathered feedback from MIT communities regarding how the DSpace system worked and how it met the needs of its users. DSpace's five early adopters communities played particularly significant roles: they tested all aspects and features of the DSpace system's submission processes. In general, they provided invaluable feedback on all of the phases and processes in which they took part.

To recruit early adopters, it's worth reminding prospects of what early participation will bring them. Early adopters benefit from the visibility that comes with blazing new trails for DSpace, a new, exciting campus-wide technology venture. Their names figure in promotional and publicity materials. They have a hand in tailoring the software and user interfaces. They get to showcase their research ahead of later entrants and reach worldwide audiences promptly. They also get special and prompt attention in solving problems.

Early adopters at MIT represented a cross-section of the Institute—groups of different sizes, submitting varied types of research, using several formats, whose disciplinary cultures and practices vary as well. They are:

- The Center for Technology, Planning and Industrial Development (CTPID)
- The Department of Ocean Engineering
- The Laboratory for Information and Decision Systems (LIDS)
- The Sloan School of Management
- The MIT Press

The DSpace Faculty Liaison¹⁰ also brought into the process five librarians, each a subject specialist with previously established ties to each of the Institute's DSpace early adopter communities, to help coordinate early adopters efforts.

The team's Faculty Liaison helped early adopters define their communities, which involved, among other things:

- Identifying the members of their community
- Establishing a list of who plays what role in the submission and review processes
- Identifying a member in charge of coordinating the community's setting of policy
- Guiding individual communities to make policy decisions affecting the submission and access policies governing their collections. These decisions were made at the highest level of the community, often after several meetings with the Faculty Liaison.
- Identifying the DSpace Coordinator, who stands as the liaison to the DSpace team, and works directly with the team's Faculty Liaison to manage these various steps in setting up the community to get it going.

DSpace support includes helping each community establish and name its collections as well as create and test its workflows for submission and review; providing guidance in creating metadata (preferably using existing controlled vocabularies to standardize metadata input); assisting with customizing individual community portal pages; and, finally, helping early adopter communities load and submit their content.

The Transition

The DSpace project was moving ahead on all fronts. In the fall of 2001, it was time for the MIT Libraries to turn to how to introduce DSpace services into the Libraries' daily operations. A Transition Team was convened in late 2001 to begin the process of

¹⁰ Librarian Margret Branschofsky, whose long experience within the MIT Libraries turned out to be invaluable, joined the DSpace team as Faculty Liaison and User Support Manager in the spring of 2000.

ushering DSpace services into the broader set of increasingly electronic services the MIT Libraries provides its patrons. The team was made up of librarians from each of MIT's individual libraries as well as representatives from technology, technical services, and public services areas.

The transition team sought to assess the impact this new service would have on the Libraries staff: what staff would be needed, how much time would staff need to allocate to DSpace work, etc.... The results of this impact analysis can be read in [The Report of the DSpace Transition Planning Group to the MIT Libraries Steering Committee](#).

To bring full awareness of DSpace to the staff of the Libraries, the transition team and others readied a host of documents, many of which remain available as help documents on the <http://libraries.mit.edu/dspace-fed-test/> web site. In addition a FAQ, geared to librarians, provides answers to some of the most frequently asked questions. It includes information among other things regarding policies; services; DSpace's relationship to such kindred campus-wide projects as OpenCourseWare (<http://ocw.mit.edu/index.html>); and whom to contact with questions. The DSpace team also planned formal trainings and a less formal brown-bag lunch to complement the occasional updates the Libraries staff heard about DSpace at periodic all-staff meetings.

The transition team also recommended some organizational changes that MIT Libraries implemented:

- It recommended putting in place the DSpace@MIT Policy Committee to create, refine, monitor, and enforce DSpace policies.
- It recommended putting in place the DSpace Advisory Committee
- It recommended the creation of two staff positions, namely the DSpace Systems Manager and the DSpace User Support Manager.

Conclusion

Every institution seeking to implement, tweak, and tailor the DSpace system to its own environment will find that building both awareness and user demand among the

institution's constituencies before determining their own technological specifications will help raise issues by which to define services and set policy. Creating an appropriate, management, staffing, and advisory structure that suits the institution's culture is indispensable. An operations plan spelling out system back-up and recovery policies and procedures needs to be put in place.

Each institution will have to elaborate its own governance structure to introduce and sustain DSpace in their environment. At MIT governance takes place thanks to a combination of advisors, from inside and outside the Libraries, working with the MIT Libraries' Associate Director of Technology, in addition to a dedicated staff maintaining the system and providing community-user and end-user support. We strongly recommend involving librarians in the process of implementing DSpace.

Each institution will need to define the content its DSpace implementation is meant to handle. Whether scholarship like MIT, or administrative records, or electronic theses, the content will drive both the software customization, what policies need to be addressed, what services will be offered and, in general, what the repository's reason for being is in its host institution.

Throughout the process, the librarian members of the DSpace team wore many hats: they translated and served as ambassadors between the rest of the team and everyone else within and without the Libraries. This role needs to be maintained well after DSpace is implemented in order to make sure that non-technical library staff may continue to contribute to the continued evolution of user-centered DSpace services.