Essay: Current Status of Trustworthy Systems

by Nancy Y. McGovern in *Building Trustworthy Digital Repositories: Theory and Implementation*, 2016

Introduction

The digital preservation community has made notable advances towards understanding and engaging in good practice since the release of the *Preserving Digital Information* report was released almost 20 years ago in 1996. The authors assessed the state of practice to define the scope and challenges of digital preservation for the community to address. The report represents a seminal moment and an identifiable starting point for measuring progress. Two decades later, the need to respond to the rapid pace of technological change remains an inherent challenge for the long-term preservation of digital content that informs the ongoing struggle to establish and maintain effective and durable digital preservation programs.

In the archival community, the management of archival records in digital form began in the 1960s at national archives in a number of countries.[1] There have also been data archives programs that have preserved digital content since the 1960s, a portion of which are records and all of which are part of the record of science and practice.[2] Unlike the library community where digitization of physical was embraced from the late 1980s on, the archival community has only more recently, for a variety of reasons, moved to digitize its physical collections at a greater scale.[3] To consider the progress so far in the archival community in managing digital records, both born digital and digitized, across generations of technology, this chapter uses known digital preservation standards and models as a frame for assessment.[4]

Emerging standards and practice

The 1996 report made explicit the requirement that organizations responsible for preserving digital content would have to transparently demonstrate good practice to enable the

creators and users of digital content to rely upon them. Since 1996, a foundation of digital preservation standards has emerged, that have provided some metrics for measuring progress. Beginning in 1995, an international group of practitioners and researchers formed working groups to address the challenges of preserving digital content that resulted in the Open Archival Information System (OAIS) Reference Model, which was adopted as ISO 14721 in 2003. OAIS has informed much of the research and development on digital preservation since before the standard was even approved. With the 2012 revision and the projected 2017 revision underway, OAIS is positioned to continue to guide good practice. Adoption of OAIS was quicker in the library and other communities than within the archival community, possibly because there were existing digital archives practices in place with a track record extending over decades and other communities were typically adopting rather than reforming existing practice to adopt OAIS.

To provide a pathway for organizations to respond to the then emerging OAIS standard, the *Trusted Digital Repositories: Attributes and Responsibilities* document was released in 2002, the result of a community effort that was sponsored by RLG. Since then, organizations that have accepted responsibility for preserving digital content have been referred to as repositories and more and more repositories acknowledge the need to be recognized as a trusted digital repository (TDR). OAIS and TDR form the foundation for good practice in digital preservation, standards and guidance that has made progress possible. The OAIS document specifies additional standards that are necessary to fully engage in digital preservation and since 2003, a number of these standards have been added to the growing family of OAIS standards. The set of standards needed for digital preservation has been identified on a development roadmap that has been included in OAIS since the first version. One of these standards formalizes and specifies the interaction between the producer of digital content and the archives in transferring responsibility

for preserving the content (PAIMAS), a crucial portion of the life cycle for managing digital records in accordance with record-keeping standards.[5] There is another community-based standard for preservation metadata, PREMIS, that is increasingly viewed as a norm for good practice.[6] The 2011 version of PREMIS added in the capability of managing rights that are associated with digital content in a manner that addresses the requirements of digital records more effectively and version 3 was released in 2013. Finally, there is the *Audit and Certification of Trustworthy Digital Repositories* (ISO 16363:2012) that is based on TRAC.[7] These examples demonstrate that the community is working on standards and practice in an effort to keep pace with evolving requirements, increasing capacity, and emerging technologies.

Measuring progress

The community model adopted for this assessment is the Digital Preservation Management (DPM) model.[8] The DPM model defines a comprehensive framework for developing a sustainable digital preservation program. The DPM three-legged stool defines the three core components that need to be in place and in balance to develop and maintain a comprehensive digital preservation program. By deconstructing the components of digital preservation into manageable chunks, repositories are able to construct programs that are suited to their needs. There has been a tendency in discussing digital preservation to presume that infrastructure refers only to the software and equipment that may be needed. But digital preservation is not a technology-only problem so the legs of the stool identify the three essential components of the infrastructure a repository needs to be develop and balance to build and implement an effective digital preservation program. The organizational leg includes policy development, decision-making, skills development, preservation planning, and other

organizational activities that define and guide the program. The technological infrastructure includes the software, hardware, automated workflows, skills, and other technology-related components needed to instantiate and sustain a digital preservation program. The resources leg includes the funding, human resources, technological and other resources needed grow and sustain the program. The three legs, as depicted in figure 1 below, define 'what' (organizational leg) the scope of the repository's digital preservation program needs to be and 'how' (technological leg) the technology will enable the repository to achieve the program's objectives making it possible to determine 'how much' (resources leg) it will cost to sustain the digital preservation program that will be needed to meet the repository's requirements.

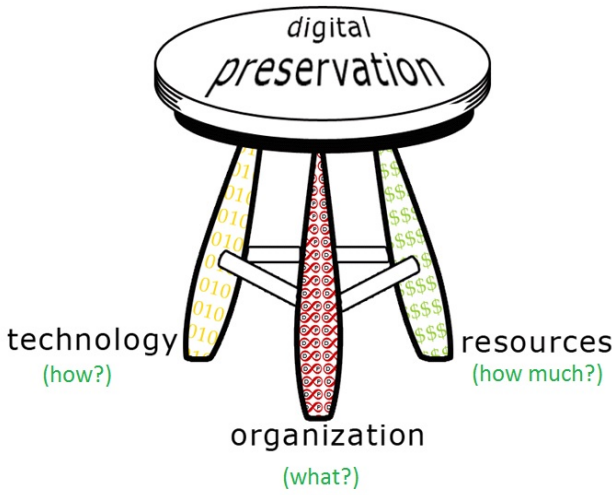

Figure 1. Digital Preservation Management (DPM) three-legged stool.[9]

The DPM maturity model identifies five stages repositories advance through in developing each of the three legs of the stool to build a sustainable digital preservation program:

1. ***Acknowledge****:* accept that digital preservation is a local concern that the repository intends to take responsibility for and work to address.

2. ***Act:*** initiate one or more digital preservation projects to address a specific need or requirement. The repository moves toward stage 3 when it realizes that a project-only approach is exhausting and that projects by definition end so cannot sustain a program.
3. ***Consolidate:*** segue from projects to programs and begin to use projects strategically to develop and maintain a basic, comprehensive digital preservation program that conforms to standards and enables the repository to demonstrate good practice.
4. ***Institutionalize:*** coordinate activities across the institution to rationalize the component parts of the program and enable the program to scale up and sustain itself.
5. ***Externalize:*** embrace inter-institutional collaboration. At least one repository needs to be at stage 4 for stage 5 collaboration to be possible; prior to stage 4 interactions between repositories are characterized as coordination, lacking the interdependency that true collaboration requires.

The launch of the DPM workshop series in 2003 almost coincided with the release of JHOVE, an open source file format identification and validation application that could be considered the first digital preservation tool.[10] The standards that guide good practice were just emerging and organizations that had begun to work on digital preservation were at early stages of development so the technology leg sessions in the first workshops, by necessity, had to focus on managing file formats and storage media. Now more than a decade later, the focus of technology leg sessions has been on developing and using standards-compliant workflows and on the selection of tools and software for repository management. As repositories move through the five stages, it becomes evident to them that the real challenges of digital preservation are the human ones – developing the ability to make informed technology investments, hiring and retaining staff with appropriate expertise, developing policies and the capacity to create rules to address a growing

range of digital content types and requirements. In a dozen years, the technology that is available to digital preservation programs has advanced relatively quickly. The five stages apply to the development of the technologies in use and of the skills needed to implement and use these technologies, as well as to overall community development, a topic the conclusion of this chapter will revisit.

It is common in an emerging domain such as digital preservation for the terminology used within the community to also be evolving and emerging as technological change requires adaptive change in relevant standards and practice. In practice, the term repository may refer to an organization that is responsible for preserving digital content or to software that an organization may implement to engage in digital preservation. This chapter uses the organizational definition of repository, involving all three legs of the stool, and adapts the attributes of a TDR frame to consider the progress of organizations in developing the wherewithal to build and sustain digital preservation programs. Similarly, the term system can be defined in a number of ways from a computer program to 'a set of principles or procedures according to which something is done; an organized scheme or method.'[11] This chapter uses the term repository to refer to an organization, inclusive of its software and hardware, which has committed to preserving specified digital content. The assessment will refer to evidence of progress in developing the three legs of a digital preservation program.

With this community context as background, the remainder of this chapter uses the seven attributes of a trusted digital repository (TDR) as a frame to discuss and refer to indicators of digital preservation progress generally and within the archival community:

1. OAIS Compliance: developing a repository in accordance with the standard.
2. Administrative Responsibility: an explicit, high-level commitment to digital preservation.

3. Organizational Viability: demonstrating the wherewithal to engage in good practice.
4. Financial Sustainability: designating funding to sustaining a digital preservation program.
5. Technological and procedural suitability: investing in a well-formed repository.
6. Systems Security: protecting preserved content every day and in emergencies.
7. Procedural accountability: documenting good practice with evidence.

The majority of the examples provided are from the US, though international examples are included whenever possible. The conclusion of the chapter consolidates the results of the review and provides some general observations about digital preservation progress within the archival community.

TDR Attributes as a frame for progress

This section reviews each of the seven attributes of a trusted digital repository (TDR) with examples from the archival community highlighted.

OAIS Compliance

A TDR must commit to aligning in some way with OAIS, whether designing its technology leg specifically in accordance with the standard or mapping to it in a more conceptual way. From the early days of its development, OAIS has had its advocates and detractors, though to date there is no other model for digital preservation that is as comprehensive, extensible, applicable, or widely used. Other models that specialize in some way, such as records management requirements, can be mapped as a layer to OAIS, for example. If an alternative model emerges, the community will vet it in the same way it has OAIS and its emerging family of standards.

The development of Archivematica, a digital preservation workflow environment that explicitly deconstructs OAIS, is significant in considering the progress of the archival community because it was specifically developed to address the preservation of archival records in digital form, because its development was initiated by an archivist and archivists have been actively involved in its development from the start, and because all of the information about its development has been shared from the start with the community making it an important tool for training and raising awareness.

As noted previously, there are some indicators that the archival community may have taken longer than some other communities to embrace OAIS. PAIMAS is a good example. The intent to develop a standard like PAIMAS was called out on the standards roadmap in OAIS document and ISO adopted PAIMAS in 2005. In an article published in the American Archivist in 2008 well after the adoption of PAIMAS by ISO, an author noted that "…the Open Archival Information System (OAIS) reference model is deficient because it ignores the need for pre-ingest archival activity."[12] A review of PAIMAS demonstrates that it formalizes the essential interaction between the creator or producer of content and the archives in a way that easily maps to records scheduling, appraisal, accessioning, and processing as well as any other pre-ingest use case, but the archival community developed a perception that OAIS did not address just these essential parts of archival management. There is now a specification called PAIS to help implement PAIMAS. If the archival community had been quicker to accept OAIS and its related standards and developments, more progress may have occurred sooner with the possibility of leveraging relevant developments underway in other communities that may have more resources.

Administrative Responsibility

An explicit, high-level commitment by a repository to engage in digital preservation is a showstopper in the pursuit of TDR status. Absent that type of commitment it is not possible to establish a well-formed and sustainable digital preservation program. The best indicators that a candidate TDR has addressed this attribute are a mission statement that explicitly identifies the necessity of the long-term management of content and a high-level policy document that capture the scope, purpose, objectives, and approach to digital preservation as a frame for its commitment. Periodically over the past twenty years of emerging good practice, there have been community discussions about the need for and examples of policy documents for digital preservation.[13] Initially, there seemed to be more examples of policy documents from other communities, but there are more and more examples of digital preservation policies in the archival community.[14]

One confusion in the digital preservation community has been that the term policy can refer to a number of different things from high-level or lower-level organizational that are the responsibility of the organizational leg too develop to individual policy statements that should be crafted collaboratively by the organizational and technological legs depending on how the need for the policy statement emerges to encoded statements that are actionable by computers enabling automation of workflows and other preservation-oriented activities.[15]

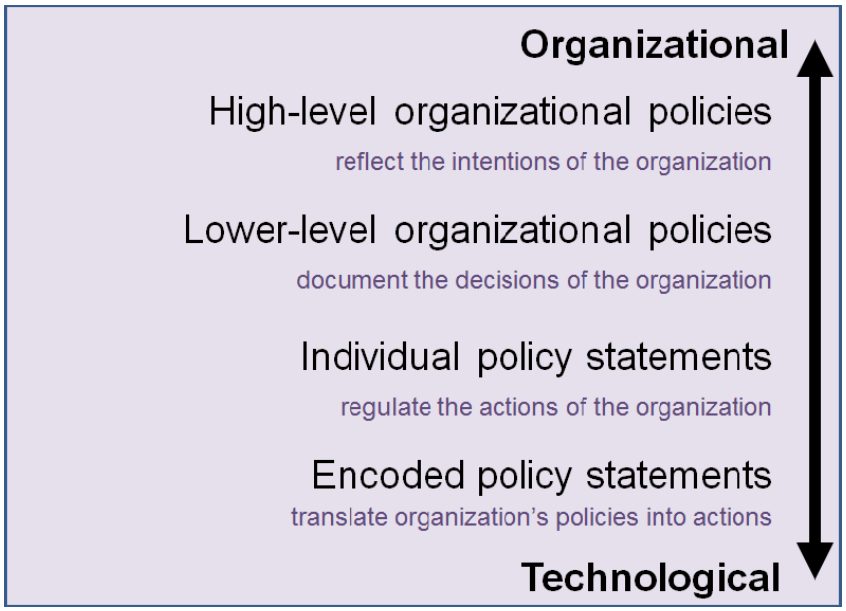

Figure 2. The levels and interactions of the policy continuum.

Referring to each of the levels as policy leads to misunderstanding and challenges collaborative efforts between the organizational and technology legs. For example, when the technology leg asks to see policies the reference is typically to the bottom two layers and the organizational leg will typically respond with an example from the top two layers because the term policy is used in such different ways. The SafeArchive project represents one example of a project that was developed to handle archival content and understood the layers of the policy continuum as represented in Figure 2. As the digital preservation community matures, discussions of the roles and outcomes of decision making are becoming more productive.[16]

Organizational Viability

The organizational viability attribute refers to the demonstrated wherewithal of a repository to preserve digital content and for this review, specifically digital records. The organizational wherewithal to establish and sustain a digital preservation program includes the people and skills, the legal status, the resources (which are referenced here and specifically

called out in the resources leg), and the ongoing intention by the repository to engage in local and community-oriented efforts to ensure the long-term preservation of specified digital content. The increase in development of digital archives that have a preservation mandate, the number of the programs that have been in place for multiple years, the increase in job postings for digital archivists, and the number of archivists presenting at and participating in digital preservation conferences are all indicators that the archival community is making progress in addressing the organizational viability attribute of a TDR.[17] A significant portion of the development and promulgation of digital forensics practices in digital preservation has been led or informed by archivists with digital archives and digital preservation expertise.[18]

The challenge of preservation metadata management is a component of digital preservation that can be particularly daunting for archives. Archival practice relies upon complex metadata to achieve good practice in managing records in any form. Archivists sit at the intersection of evolving approaches to discovery and use for digital content that can increasingly include archival records, emerging techniques for integrating and curating the growing mass of metadata required for all aspects of good practice, and ongoing requirements that the chain of custody of records is documented and preserved, often relying upon metadata to do so. The technologies discussed below for technological and procedural suitability are increasingly able to address archival requirements and potentially along with non-archival content. Many of these tools are able to meet both digital preservation metadata requirements, including PREMIS metadata generation and management, and archival metadata requirements. There are very hopeful signs and the digital community as a whole has a ways to go before truly comprehensive and integrated discovery and use of all content while still addressing specific needs like archival requirements is widely available.

Financial Sustainability

The financial sustainability attribute requires that a repository demonstrate sound fiduciary management practices and make a compelling for the ways in which the repository is and will designate funding to sustain their digital preservation program. Making a compelling case does not require that the repository identify specific budget lines, but does require demonstrating a deep understanding of the nature of long-term preservation costs and delineating a convincing approach and commitment to affording those costs with the reality and challenge that most organizational budgets are approved annually. Unlike the organizational leg that has the TDR document as its good practice frame and the technological leg that has OAIS as its reference model for good practice, the resources leg does not yet have a community document to frame it. There has been quite a lot of community-based work to better understand good practice for managing the resources leg. Most notably these include the outcomes of the multiple phases of development of the LIFE project in the UK that specified to help repositories quantify their digital preservation costs; the work of the Collaboration to Clarify the Costs of Curation (4C) a project funded by the European Union that resulted in a community-based tool called the Curation Cost Exchange to help the community understand, document, compare, and share digital preservation cost information; and the work of the Blue Ribbon Task Force on Sustainable Preservation and Access (BRTF-SPA) that produced its final report in 2010. [19] It is interesting to note that the BRTF-SPA case studies do not include an archives case study. In response to questions about the lack of a case study for archives, the task force explained their rationale that the mandate archives have requiring them to preserve records should mean that there is no need for a case study to investigate and justify the digital preservation cost model for

archives. The discussion that followed when the topic came up explained that archives cannot rely upon their mandate to ensure designated funding for digital preservation and like other repositories, need to provide a compelling case. Now that there is a deepening understanding of the what (organizational leg issues) and the how (technological leg issues), the digital preservation community is having more productive discussions of the cost (how much) issues, addressing the resources leg in a more informed and productive manner. There are more and more cost model examples from archives a sign of progress.

Technological and procedural suitability

The discussion above of the OAIS compliance attribute in part addresses the technological and procedural accountability attribute. The OAIS reference model describes what the technology leg needs to be able to do, though appropriate to the purpose and definition of a reference model not how the repository choses to address OAIS. The detailed OAIS model illustrates the many ways in which repositories are expected to specify and document what their digital preservation actions in real-time and over-time, preserving the record of good practice. The approach by the emerging set of digital preservation tools, including ArchiveSpace, BitCurator, Archivematica, Preservica, and others, assists repositories in meeting their requirements and objectives by capturing and helping to manage the cumulative set of preservation metadata that is required for good practice in digital preservation. Within the last two years, these and other tools have reached version 1.0, an indication that the technologies are shifting from project (stage 2) to production (stage 3). Providers and partners in digital preservation tools and services are increasingly collaborating to provide integration pathways for building a strong technology leg. Prior to the emergence of these tools, archivists were

reasonably concerned that developments and practice within the broader digital preservation community could not address the requirement of preserving and managing digital records. Now that options that are appropriate for digital records are available, more and more archivists are involved in ensuring that archival use cases can be met and an increasing number of archives are implementing or subscribing to these tools and services. The partnerships between the Bentley Library at the University of Michigan and Archivematica and between Yale, ArchiveSpace, and Preservica are excellent examples of digital preservation progress in the archival community.

Systems Security

The systems security attribute is important for any repository in becoming a TDR, addressing both everyday operational and emergency response security concerns. Archives, like any repository that may be responsible for preserving confidential information, must demonstrate the ability to address relevant laws, regulations, contractual agreements, donor requirements, and other requirements that may require additional security protocols and practices. Service providers like Arkivum and DuraCloud are partnering with archives to develop and implement preservation storage solutions that are able to address archival requirements, including the long-term preservation of confidential digital records. The system security use cases for archives will continue to be defined and addressed as requirements and enabling technologies evolve. The ability of archivists to engage so productively in these ongoing discussions is a sign of progress for both the archival community and the digital community.

Procedural accountability

The procedural accountability attribute recognizes the need for repositories to provide evidence that a repository is aligning with standards and practice. Over time, the documentation required to demonstrate good practice by the repository must be preserved as evidence that a repository is engaged in good practice, completing periodic self-assessments and audits, and produced as needed for auditors, peers, and stakeholders. Once understood as good practice recordkeeping, the requirement is one that is easily understood by archivists.

There have been repository test audits since 2006 to vet the Trustworthy Repository Audit and Certification (TRAC) requirements before their public release in early 2007.[20] With the release of the TRAC requirements, David Giaretta, one of the TRAC authors and a primary developer of OAIS, convened a CCSDS birds-of-a-feather group to produce an ISO standard using TRAC as the base.[21] Another round of test audits preceded the approval of the final version of the requirements, as ISO 16363 in 2012. Since the 1996 *Preserving Digital Information* report stressed the need for certification to demonstrate good practice and especially with the availability of the TRAC then ISO 16363 metrics, there has been a growing community expectation that repositories will engage in self-assessment, audit, and possibly certification using a "show me" rather than "trust me" approach. Archivists have been involved with the development of all of the major digital preservation standards, including Bruce Ambacher who co-chaired the RLG/NARA task force that produced TRAC.[22] There has been an increase in the number of archives among repositories that are recognizing the need to demonstrate procedural accountability for their digital archives programs.[23]

Conclusion

In any community, digital preservation programs emerge in greater numbers when there is an increasing reliance on digital content, when there are losses of digital content or near misses, when the amount of born digital content to be preserved increases, when growing digital collections push repositories to view digital content as assets or investments, when the available digital preservation expertise to do what needs to be done expands, when the requisite resources to preserve digital content are allocated or reallocated by a repository, and when common standards and sufficient technical capacity enable repositories to begin to achieve outcomes. All of these factors are increasingly true for archives to a greater or lesser extent across the breadth of the archival community. In the first decade after the release of the 1996 Preserving Digital Information report, it seemed that other communities were making more digital preservation progress than the archival community. For the past five years if not the whole of the past decade, progress within the archival community is speeding up and the archival community's portion of the digital preservation community is growing. If that is not already true – and an intensive study would be needed to prove it, a sign of progress is that it can now become true. If the overall stage of development of the digital preservation community is climbing towards the basic programs achieved at stage 3, the archival community is demonstrating the potential and determination to move beyond the project focus of stage 2. At stage 3, projects are used strategically by programs to achieve outcomes and the archival community is already engaged in doing that more often as digital preservation programs emerge.

Beyond the progress noted in digital records management throughout this chapter, the Radcliffe meetings on Technology and Archival Processing that began in 2010 are one indicator that the management of both physical and digital collections in archives are aligning in ways that are necessary and can now enable discussions about priorities and strategies that will hopefully

reunite the archival community in some ways that have not been possible since the early electronic records programs were launched in the 1960s and since when physical and digital archival practice diverged when convergence would be some much more productive.

In the past several years, there has been an increase in the number of digital preservation projects and conference sessions that are lobbying for a move from theory to action.[24] Phrasing their perceived need for action in this way causes confusion within an applied field like digital preservation that has been developing and evolving good practice for decades because theory can be understood in a number of ways, not all of which correctly reflect the status of practice aligned with standards within the community. Though theory can refer to a set of principles that inform practice, a common definition of theory is: "an idea that is suggested or presented as possibly true but that is not known or proven to be true."[25] Therefore, calling for a shift from theory to action could suggest that good practice is not yet known or has not been proven, or it could suggest that institutions have not already been engaged in action, none of which are correct characterizations of the current status. From a DPM model perspective, these references are not a call to begin to act, but rather a community indicator of a critical mass of institutions at last experiencing a natural progression beyond awareness that there is a problem to address (stage 1) to establishing a project (stage 2) as a way of beginning to address the problem and consolidating efforts to establish basic digital preservation programs (stage 3). Recognizing the need to move from projects to programs or to shift from worrying about digital preservation to doing something about it would more correctly represent the current state of community practice and would not appear to negate the progress to date by repositories that have already been actively engaged in digital preservation.

We have a growing number of examples to demonstrate that the cumulative set of digital preservation standards and guidance can be used by repositories, including archives, as an effective frame for the ongoing preservation of digital content across generations of technology. A track record by a digital preservation program for demonstrating good practice for longer than five years can increasingly be used as an informal measure of the success of the repository. The building blocks are in place and a growing number of organizations are ready to preserve digital records in accordance with archival requirements.

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[1] For example, the U.S. National Archives machine-readable records program, now the electronic records program, began in 1967. Programs at national archives in Canada, Australia, Switzerland, and other countries began around the same time.

[2] Since 1939, the U.S. Federal Records Act included punch cards and other computerized formats were added after that. The National Archives and Records Administration has had a long-standing relationship with the Inter-university Consortium for Political and Social Research (ICPSR), a data archive that was established in 1962 and that collects data from and on behalf of federal agencies, e.g., the Departments of Justice, Census, Labor, Education, Health and Human Services, some of which meet the definition of federal records.

[3] Distinctions between the rights management models and the uniformity of materials to be digitized have been factors in the different responses in the archival and other communities.

[4] These observations and examples are based on the author's experience as an electronic records archivist from 1986 to 1996 at the U.S. National Archives; in obtaining a PhD on developing a community-based model for the digital preservation to continually respond to technological change; in serving as the lead for developing sustainable digital preservation programs at Cornell University Library, ICPSR, and now at MIT Libraries; as a researcher on collaborative research programs for more than fifteen years; and as the co-developer and director of the Digital Preservation Management (DPM) workshop series since 2003, an open source curriculum program that began in 2003 and will offer its fiftieth workshop in March 2016. The DPM program has been offered on five continents to more than 1,500 managers at all levels who are responsible for digital content of all kinds in any organizational context and who represent more than 600 organizations in more than 20 countries. Maintaining the curriculum requires a continuous scan of digital preservation research and developments and presenting the workshop provides an ongoing opportunity to hear from representative intuitions about their progress and challenges.

[5] *Producer Archive Interface Method Abstract Standard (PAIMAS)* was approved as an ISO standard in 2005 and there is a complementary specification called PAIS pending.

[6] *Preservation Metadata Implementation Strategies (PREMIS)*, v. 1.0 in 2005, v. 2.1 in 2011, v.3 in 2015.

[7] *Audit and Certification of Trustworthy Digital Repositories* (ISO 16363:2012) based on the Trustworthy Audit and Certification (TRAC) requirements that were released in January 2007.
[8] There are a number of digital preservation models that could be adapted for use in assessing progress within the archival community. Jefferson Bailey documented six digital preservation models. http://www.jeffersonbailey.com/i-review-6-digital-preservation-models-so-you-dont-have-to/. The Digital Preservation Management (DPM) maturity model is the oldest known model that has been in continuous use since it was published in 2003, presented in the first of nearly fifty workshops that same year, and used as the frame for the DPM online tutorial. It is intended and has proven to be an effective framework for developing standards-based digital preservation programs to preserve any kind of digital content in any organizational context – academic, government, nonprofit, or corporate; public or private; and large or small.
[9] Anne R. Kenney and Nancy Y. McGovern developed the DPM model in 2001 and it is described in a 2003 article, "The Five Organizational Stages of DigitalPreservation," in Digital Libraries: A Vision for the Twenty-first Century, a festschrift to honor Wendy Lougee, Ann Arbor, Michigan: University Library, 2003. This image of the stool was created by Carla DeMello at Cornell University Library.
[10] JHOVE - JSTOR/Harvard Object Validation Environment. http://jhove.sourceforge.net/
[11] See the entry for 'system' in the *Free Dictionary* and similar definitions elsewhere.
[12] Adrian Cunningham, "Digital Curation/Digital Archiving: A View from the National Archives of Australia," *American Archivist* Winter 2008.
[13] Nancy Y. McGovern, "A Digital Decade: Where Have We Been and Where Are We Going in Digital Preservation?" RLG DigiNews 11:1, April 2007. Neil Beagrie, Najla Semple, Peter Williams, and Richard Wright, *Digital Preservation Policies Study*, London: JISC, 2008. Daniel W. Noonan, "Digital Preservation Policy Framework: A Case Study," *EducauseReview*, July 2014 that is informed by the DPM workshop model and digital preservation policy framework model document, one of the DPM Management Tools.
[14] This 2013 post on the Library of Congress Signal blog includes some digital preservation policies developed by archives and archives may be organizationally part of a library with the archives specifically called out in the policy, the latter representing progress for the archival community, see: http://blogs.loc.gov/digitalpreservation/2013/08/analysis-of-current-digital-preservation-policies-archives-libraries-and-museums/.
[15] Nancy Y McGovern developed the policy continuum model for the DPM workshop and presented at the 2008 International Preservation of Digital objects (iPres) conference. The purpose of the model is to help digital preservation managers understand the layers and roles of decision-making in relation to program management.
[16] The purpose and application of SafeArchive are described at: http://www.safearchive.org/.
[17] Jane Zhang an archival educator at Catholic University has been conducting a multi-year study of the emergence and evolution of the digital archivist job description and role that she has presented on at the Annual Meetings of the Society of American Archivists (SAA) and elsewhere.
[18] The phases of development of the BitCurator environment has been led by Christopher "Cal" Lee and Kari Smith, digital archivist at MIT Libraries, is just one of the archivists who have informed its development. Both are active members of SAA and of the digital preservation community.

[19] See the LIFE website at: http://digitalcurationexchange.org/; the Curation Cost Exchange website at: http://www.curationexchange.org/; and the BRTF-SPA website at: http://blueribbontaskforce.sdsc.edu/.
[20] RLG-NARA Task Force on Digital Repository Certification, Trustworthy Repositories Audit & Certification: Criteria and Checklist, Chicago: CRL, 2007.
[21] See David Giaretta's brief biography: https://www.linkedin.com/in/davidgiaretta.
[22] Ambacher was also an active contributor to the OAIS working groups on behalf of the National Archives and Records Administration (NARA) and upon his retirement from NARA, Mark Conrad took on his role in the transformation of TRAC into ISO 16363. The TRAC authors included several archivists, including the author of this chapter.
[23] As an example, see Edward M. Corrado and Heather Lea Moulaison, *Digital Preservation for Libraries, Archives, and Museums*, Rowman & Littlefield Publishers, 2014.
[24] For example, the POWRR project (see: http://digitalpowrr.niu.edu/) and several sessions at the International Conference on the Preservation of Digital Objects (iPres) 2015 conference.
[25] Definition of the term 'theory' from the Merriam-Webster dictionary. http://www.merriam-webster.com/dictionary/theory.