InterPARES 3 Project

International Research on Permanent Authentic Records in Electronic Systems

TEAM Canada

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Author:	The InterPARES 3 Project, TEAM Canada
Writer(s):	Alexandra Allen Project Coordinator
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Overview

The objective of the Cost-Benefit General Study is to determine a measureable framework for assessing the benefit of recordkeeping systems. Although it is possible to establish the benefits of digital preservation, most organizations or institutions have only encountered the initial costs of the beginning stages of a digital preservation project. This study is not intended to determine the actual costs and benefits; it is to determine or develop the parameters that an organization should consider and examine when undertaking a cost-benefit analysis.

The Graduate Research Assistants (hereafter, GRAs) assigned to this study were responsible for developing a template that identifies the various cost and benefit parameters and that justifies why each of these parameters is relevant to such an analysis. The actual parameters that are relevant in any particular situation may change completely from one institution to another, depending on whether it is public or private, for profit or not-for-profit, international vs. national, etc. The GRAs collected preservation costs and benefit information from the InterPARES 3 TEAM Canada test-beds, as well as from other organizations.

Methodology

The principal methodology used for the general study was content analysis. The GRAs conducted a comprehensive review of existing cost benefit templates, and, from their research, were able to provide an overview of necessary elements for these models. A matrix was created to compute elements of cost benefit templates in order to compare them to identify gaps and strengths of each model. The GRAs contacted relevant InterPARES 3 TEAM Canada case studies that had preservation cost and/or benefit information in an effort to determine those costs. Collectively, the findings from the matrix and findings from relevant InterPARES case studies form the basis for inclusion in the proposed cost benefit template. Data were then presented to the TEAM Canada researchers for evaluation, discussion and recommendations at the bi-annual research plenary workshops in Vancouver.

Overview of InterPARES Test-beds

Although organizations and institutions that implement some kind of digital preservation project may encounter benefits (financial and otherwise) in the future, their digital preservation projects have incurred costs now. In response to discussions at the TEAM Canada Plenary Workshop 07, the GRAs were asked to collect preservation cost and/or benefit information from the InterPARES 3 test-beds and/or from other organizations. The GRAs contacted relevant InterPARES test-beds in an effort to determine those costs. A test-bed was considered “relevant” if an actual digital preservation project had been fully implemented at the organization or institution. Five InterPARES test-beds and one outside institution were contacted through e-mail; the responses received varied. It is impossible at this point to determine a trend in the results, as only one small organization and two large institutions were able to provide conclusive responses.

The following is a brief account of the test-beds' objectives and digital preservation costs (as applicable).

CS09 - University of British Columbia Alma Mater Society: Policies and Procedures for Web Site Preservation[1]

The Alma Mater Society at the University of British Columbia set out to create a non-technical solution for the preservation of digital web content. The expenses that were incurred included a software purchase (Adobe Pro) of $100 and a $1,000.00 fee for a contractor. The contractor was called in when an upgrade to the website blocked website saving. The costs for this project were "one-time" costs.

CS11 - University of British Columbia Graduate School of Journalism: Preservation and Access System for High Definition Digital Video Archive in Online and Electronic Formats[2]

The University of British Columbia's Graduate School of Journalism set out to establish a digital video archive (in High Definition) and to determine a means to ensure the preservation of other digital videos created by its students. The test-bed was contacted about costs associated with this project; however, the test-bed representative did not wish to disclose specific figures.

CS14 - City of Surrey: Policies, Guidelines and Procedures for a Drive Migration Project as part of an Enterprise Content Management Program[3]

The City of Surrey set out to create a Drive Migration project. This was an effort to assist staff in transferring records that were stored on shared drives to their final destination, i.e. the repository or offline storage, or prepare them for deletion. The test-bed was contacted about costs associated with its project; however, no response was received.

CS16 - City of Vancouver Archives: Requirements Analysis for a Digital Archives System[4]

The City of Vancouver Archives set out to develop and implement an OAIS-compliant Digital Archives system, articulating two phases to its project. The first phase set out to determine how to preserve public records generated by the City's ERDMS (Electronic Records and Document Management System). The second phase set out to use that system to preserve the digital records generated by VANOC.[5] The costs associated with Phase 1 included a Digital Archivist ($34,890), a Digital Curator ($34,000), a Digital Archives Consulting fee ($135, 000) and miscellaneous hardware ($5,000). The costs associated with Phase 2 included a Digital Archivist ($70,253), a Digital Curator ($35,500), a Digital Archives Consulting Fee ($148,684), and Technology Infrastructure and Storage ($99,961). The City of Vancouver Archives also provided

[1] See: http://www.interpares.org/ip3/ip3_case_studies.cfm?team=1#cs09.
[2] See: http://www.interpares.org/ip3/ip3_case_studies.cfm?team=1#cs11.
[3] See: http://www.interpares.org/ip3/ip3_case_studies.cfm?team=1#cs14.
[4] See: http://www.interpares.org/ip3/ip3_case_studies.cfm?team=1#cs16.
[5] The Vancouver Organizing Committee for the 2010 Olympic and Paralympic Winter Games.

cost projections for 2011, but, as they were not conclusive, they were not included in this report. The costs of this project are "ongoing".

Washington State Archives[6]

The Washington State Archives set out to develop and implement a digital archives to preserve electronic records from municipal and state government agencies. The goal was to preserve unique records created in the State of Washington and make them easily accessible to the public. The costs associated with the project included wages with benefits for four staff members ($275,000), a newly constructed shared-use facility ($7,500,000), hardware purchase and maintenance ($889,382), software purchase ($245,564), goods and services ($56,750), and personal services contracts ($1,069,912). The costs of this project are "ongoing".

Table 1. Consolidated digital preservation costs by test-bed or organization.

	CS09	CS11	CS14	CS16	WSA
Facility					$7,500,000
Personnel				2009: $68,890; 2010: $106,023	$275,000
Equipment	Software: $100			2009: Hardware: $5,000 2010: Storage: $99,961;	Hardware: $889,382 Software: $245,564
Consulting/ Development				2009: $135,000; 2010: $148,864	$1,069,912
Other	$1,000[7]			2009: $11,366; 2010: $2,669[8]	$56,750[9]

[6] See: http://www.sos.wa.gov/Archives/.
[7] An upgrade to the website blocked website saving. A contractor was brought in to fix the block.
[8] Not specified.
[9] Goods and Services.

Overview of Cost Models

Having an understanding of the activities necessary for the preservation of digital records is key to identifying the costs connected with a digital preservation program. These costs come from every aspect of an archives; from the generic staffing and facilities to the specific-technology and training. To make value judgments on what to preserve and the approach that will be taken, it is necessary to identify the benefits that can offset the costs. Some of these benefits are common to any organization. These 'generic' benefits include the potential for increased access by patrons and a lowered (if not eliminated) need to re-create material due to a lack of preservation. Because the ability to answer the economic questions regarding the costs of digital preservation and how they are being offset by the benefits they offer is key, it is necessary for a cost-benefit model to be created.

This report summarizes the information about cost models pertaining to digital preservation found in the readily-accessible English language literature. The report is based on the resources identified in the GS16 Annotated Bibliography.[10] A concise description of each model is presented, highlighting their strengths. Following the description of the models is an analysis that identifies the commonalities and differences that they each have. Finally, the report attempts to create a generic cost model based on the strengths of the models reviewed for this report.

KRDS1/2
Keeping Research Data Safe
(2008-2010)

This study investigated the medium to long-term costs to Higher Education Institutions (HEIs) of the preservation of research data and developed guidance to HEIs on these issues. This study provides among other outcomes:

- a list of key cost variables and potential units of record;
- an activity model; and
- a benefits framework illustrated with two benefit case studies.

Overall, the approach of the authors focused on developing a framework for determining costs. The major deliverable from the study is the costing framework.

Cost Variables

This section describes key variables that affect the cost of preservation activities. The cost variables are divided into two major groups: economic adjustments and service adjustments.

Economic adjustments consist of inflation/deflation, depreciation, infrastructure costs, and cost of return for financing and investment; that is, the major financial factors that play a role

[10] See: "General Study 16 – Cost-Benefit Models: The Cost-Benefit Analysis of Digital Preservation - Annotated Bibliography," InterPARES 3 Project, TEAM Canada (v1.3, October 2013). Available at http://www.interpares.org/ip3/display_file.cfm?doc=ip3_canada_gs16_annotated_bibliography.pdf.

in the economy on a large scale. **Service adjustments** represent the operational costs incurred by institutions while preserving data. The costs identified by the authors are summarized in Table 2, below.

Table 2. Economic/service adjustment digital preservation costs identified by KRDS1.[11]

FUNCTIONS	VARIABLES
Generic	• Staff Costs and Labour Rates • Activity Duration • Levels of Automation
Acquisition, Disposal and Ingest	• Number of Depositors • Number, Mode and Frequency of Deposits • Number, Complexity and Type of File Formats • Data Volumes • Metadata, Documentation, Ethics and IPR • Levels of Processing, Validation and Calibration • De-accessioning Costs
Archive Storage, Preservation Planning, Data Management	• Retention Period • Management and Refreshment • Number of Versions and Copies • Storage Media (capacity, costs) • Archive media monitoring
Access	• Number of Users and User Communities • Standard or Custom Interfaces • Level of User Support • Access Control • Number and Volume of Accesses • Access/Distribution Method • Service Response Times • Processed Products

Activity Model

The KRDS Activity Model, first presented in KRDS1 and replaced by KRDS2, identifies activities with cost implications for preservation. This is sub-divided into Pre-Archive, Archive, and Support Services. Typically, Pre-Archive activities relate to research projects in universities, and archive activities to data archiving repositories run by universities or third-parties. Both of these relate to lifecycle costs for research data. Activities in Support Services can support either Pre-Archive or Archive activities and typically will be part of the existing infrastructure for

[11] Source: Neil Beagrie, Julia Chruszcz, and Brian Lavoie, "Keeping Research Data Safe: A Cost Model and Guidance for UK Universities 2," JISC Final Report, April 2008. Available at http://www.jisc.ac.uk/media/documents/publications/keepingresearchdatasafe0408.pdf.

finance, IT and other common services; these are included in calculating full economic costs. The key activities, functions and actions of the Activity Model are summarized in Table 3, below.

Table 3. KRDS2 Activity Model: Activities, Functions and Actions.[12]

ACTIVITIES	FUNCTIONS	ACTIONS
Pre-Archive Phase Research projects in universities creating research data for later transfer to a data archive. However activities can be adapted for first stages in piloting and development of a new data archive if required.	Outreach	Guidance on best practice and archiving requirements and other support and training by the archive for researchers submitting funding proposals or creating research data.
	Initiation	Project design
		Data management plan
		Funding application
		Project implementation
	Creation	Negotiate IPR/licensing/ ethics
		Generate descriptive metadata
		Generate user documentation
		Generate customized software
		Data management
		Create submission package for archive
Archive Phase The activities required for long-term archiving of research data.	Acquisition	Selection
		Negotiate submission agreement
		Depositor support
	Disposal	Transfer to another archive
		Destroy
	Ingest	Receive submission
		Quality assurance
		Generate information package for archive
		Generate administrative metadata
		Generate/upgrade descriptive metadata and documentation
		Co-ordinate updates
		Reference linking

[12] Source: Neil Beagrie, Brian Lavoie, and Matthew Wollard, "Keeping Research Data Safe 2," JISC Final Report, April 2010. Available at http://www.jisc.ac.uk/media/documents/publications/reports/2010/keepingresearchdatasafe2.pdf.

	Archive Storage	Receive data from ingest
		Manage storage hierarchy
		Replace media
		Disaster recovery
		Error checking
		Provide copies to access
	Preservation Planning	Monitor designated user community
		Monitor technology
		Develop preservation strategies and standards
		Develop packaging designs and migration plans
		Develop and monitor SLAs for outsourced preservation
		Preservation action
		Generate preservation metadata
	First Mover Innovation	Develop community data standards and best practice
		Share development of preservation systems and tools
		Engage with vendors
	Data Management	Administer database
		Perform queries
		Generate report
		Receive database updates
	Access	Search and ordering
		Generate information package for dissemination to user
		Deliver response
		User support
		New product generation
Support Services Services and functions needed to control the operation of the other functional entities on	Administration	General management
		Customer accounts
		Administrative support
		Develop policies and standards
	Common	Operating system services

a day-to-day basis.	Services	Network services
		Network security services
		Software licenses and hardware maintenance
		Physical security
		Utilities
		Supplies inventory and logistics
		Staff training and development
Estates	Estates management and attendant costs includes leasing of premises, space management and maintenance.	

The authors stress that the Activity Model is generic and that end-users must tailor it to their specific institution and requirements. The Activity Model is designed for costing preservation activities where there is a distinct archiving phase based on a designated archive centre or function. There are specific research disciplines and sub-disciplines where this is not the norm, such as when preservation is done by a research group or even by an individual researcher. The KRDS2 Activity Model contains many activities and sub-activities that are relevant to preservation in these scenarios, but the presentation and structure of the KRDS2 Activity Model itself will need significant future adaptation if it is to be tailored specifically for them. Also, the KRDS2 Activity Model could be applied at different levels for different purposes. The choice of activity level greatly affects the accuracy and cost of developing and maintaining the model. Detailed activity modeling is usually needed for operations planning and process improvement, whereas more general, high-level activity models are sufficient for cost management.

Benefits Taxonomy

The authors stipulate that analysis of the costs of preserving research data sets is not enough to assess the economic feasibility of a particular digital preservation activity. Cost analysis should be accompanied by a framing of the benefits from preservation—in other words, the value that is anticipated to emerge from the investment in maintaining the long-term existence and accessibility of research data. A taxonomy for categorizing the benefits from long-term preservation of research data is presented in Table 4, below.

Table 4. KRDS2: Benefits taxonomy for long-term preservation of research data.[13]

Dimension 1	
Direct Benefits	*Indirect Benefits (Costs Avoided)*
• New research opportunities • Scholarly communication/access to data • Re-purposing and re-use of data • Increasing research productivity • Stimulating new networks/collaborations • Knowledge transfer to industry • Skills base • Increasing productivity/economic growth • Verification of research/research integrity • Fulfilling mandate(s)	• No re-creation of data • No loss of future research opportunities • Lower future preservation costs • Re-purposing data for new audiences • Re-purposing methodologies • Use by new audiences • Protecting returns on earlier investments
Dimension 2	
Near-Term Benefits	*Long-Term Benefits*
• Value to current researcher & students • No data lost from Post Doc turnover • Short-term re-use of well curated data • Secure storage for data intensive research • Availability of data underpinning journal articles	• Secures value to future researchers & students. • Adds value over time as collection grows and develops critical mass
Dimension 3	
Private Benefits	*Public Benefits*
• Benefits to sponsor/funder of research/archive • Benefits to researcher • Fulfill grant obligations • Increased visibility/citation • Commercializing research	• Input for future research • Motivating new research • Catalyzing new companies and high skills employment

OAIS REFERENCE MODEL
Open Archival Information System
(2002)

The Open Archival Information System (OAIS) Reference Model focuses on digital information that has been selected for long-term preservation. Long-term is viewed as long enough that changes in technology will impact the information. These changes include new formats and changes in the user community. The OAIS model is designed as a framework for facilitating the

[13] Ibidem.

understanding of archival concepts pertaining to the model focus for participants from non-archival organizations. The model provides frameworks for comparing: operations and architectures of future and existing archives; different strategies and techniques in digital preservation; and preservation models and their changes over time through technology. The OAIS model also functions as a guide to identifying and producing related standards as well as increasing the consensus on the processes and elements for preservation and access. Due to the nature of digital records, it is difficult (if not impossible) to separate preservation costs from those of access.

Digital preservation potentially makes many other services possible, including distributed delivery, which can be used to support some of the costs. The costs of digital preservation correlate inversely to the benefit of reduced storage prices, such that:

- image compression typically comes at the price of introducing irreversible quality losses to grayscale and colour images;
- someone must monitor not only potential obsolescence of the format, but also a compression algorithm; and
- migration or other transformations will need to be scheduled at shorter intervals than for uncompressed formats.

Additionally, it is necessary to have a preservation strategy that is appropriate to the perceived value of the digital object. This can be a costly decision since the long-term value of digital materials can be difficult to determine due to changing technology, a fact that often requires that decisions about long-term value be made before the technology is proven.

Functions/Actions Model

The OAIS model divides preservation costs into six functions specific to digital preservation and one function general to archives. The specific functions are: Ingest, Archival Storage, Data Management, Administration, Preservation Planning and Access (see Table 5, below). The authors discuss these in their order of occurrence within the collection manager's workflow.

Table 5. OAIS Model: Functions and actions.[14]

FUNCTIONS	ACTIONS
Ingest	Receiving Submission Information Package (SIP)
	Performing quality assurance
	Generating an Archival Information Package (AIP)
	Extracting Descriptive Information

[14] Source: Consultative Committee for Space Data Systems (CCSDS), "Reference Model for an Open Archival Information System (OAIS): Recommendation for Space Data System Standards," CCSDS 650.0-B-1, *Blue Book*, Issue 1 (January 2002). Available at http://public.ccsds.org/publications/archive/650x0b1s.pdf. [Note: As of 2012, this document has been superseded. A new issue, CCSDS 650.0-M-2, is available at http://public.ccsds.org/publications/archive/650x0m2.pdf.]

	Coordinating updates to Archival Storage and Data Management
Archival Storage	Receiving AIPs and adding them to permanent storage
	Managing the storage hierarchy
	Refreshing the media on which archive holdings are stored
	Performing routine and special error checking
	Providing disaster recovery capabilities
	Providing access to fulfill orders
Data Management	Administering the archive database functions
	Maintaining schema
	Viewing definitions
	Maintaining referential integrity
	Performing database updates
	Loading new descriptive information
	Loading new archive administrative data
	Performing queries on the data management data
	Producing reports
Administration	Soliciting and negotiating submission agreements
	Ensuring that submission agreements meet archive standards
	Maintaining configuration management of system hardware and software
	System engineering functions • Monitoring archive operations • Improving archive operations
	Inventorying archive contents
	Reporting on archive contents
	Migrating/updating the contents of the archive
	Establishing and maintaining archive standards and policies
	Providing customer support
	Activating stored requests
Preservation Planning	Evaluating archival content
	Recommending archival updates
	Developing recommendations for archive standards and policies

	Monitoring changes in technology
	Monitoring changes in Designated Community's requirements
	Designing IP templates
	Reviewing templates for SIPs and AIPs
	Developing detailed Migration plans
	Developing software prototypes • Testing to implement migration goals
Access	Communicating with Consumers
	Applying controls to specially protected information,
	Coordinating the execution of requests
	Generating responses
	Delivering the responses to Consumers

Benefits

The authors agree that emerging models for digital preservation illustrate that not all storage environments are equal. The primary approach suggested to take advantage of, and increase the benefits of, digital preservation is collaboration, particularly because it takes advantage of the economies of scale. Optimizing environments, or sending materials to optimal locations, are both methods proven to minimize risk of obsolescence for large volumes of material. Minimizing this risk generates an indirect benefit of not having to recreate the information at a later date. All of the authors indicate that collaboration is a necessary part of a successful digital preservation strategy. These benefits are linked with the policies for the selection of the material and the significance of these benefits is related to the level of commitment, resources and expertise of all involved parties, as well as what level of cooperation is taking place, whether it is international, national or regional. Collaboration can take place at any stage of preservation, including during the selection of material, copyright negotiations, and the administration of the archives.

ERPANET
Electronic Resource Preservation and Access Network[15]
(2003)

The ERPANET project, funded by the European Commission, established a knowledge base of best practices and skills in the area of digital preservation of cultural heritage and scientific objects. Different cost orientation tools developed by the project help users examine the costing issues involved in digital preservation.

[15] See: http://www.erpanet.org/.

Cost Factors

Table 6, below, identifies cost factors that should be taken into consideration, and which should and can be integrated into the existing business context.

Table 6. ERPANET: Digital preservation factors, issues and cost impacts.[16]

FACTORS	ISSUES	COST IMPACTS
Objects	Influence on creation	Less influence means mostly higher costs.
	Existing	Existing objects require more work to prepare for ingest and storage.
	Complexity	The growing complexity of objects entails more maintenance.
	Preservation period	Long-term retention entails longer maintenance.
	Appraisal/value	The intrinsic value of the information objects has to be established. Consequent and sound appraisal also helps to reduce costs.
People	Skills	Specific skills are required.
	Quality	Well trained, skillful and experienced people re expensive, but will reduce overall costs.
	Training	Training needs to be up-to-date and adequate depending on the job-function. This requires funding.
	Experience	With a growing level of experience, less inadvertent accidents will happen.
Standards	Standards	Use of standards will lower the effort of own development and, at the same time, facilitate long-living solutions. Format standards help in reducing the maintenance and ease migration procedures.
Practices	Workflow	Needs to be coherent and consistent
	Operation	Costs include people, material. Adequate and efficient software tools will minimize human intervention and accelerate processes.
	Processes	Each of the processes should be cost effective.

[16] Source: ERPANet (Electronic Resource Preservation and Access Network), "Erpaguidance: Cost orientation tool," Information Society Technologies, September 2003. Available at http://www.erpanet.org/guidance/docs/ERPANETCostingTool.pdf.

Systems, Methods and Technologies	Preservation method	Each type will have a different costing-profile. It may be necessary to employ multiple preservation methods in parallel.
	Validation of methods	Validation of the potential success of a method is necessary before using it.
	Sustainability	Methods should be chosen with the idea that they survive several generations of IT.
	Portability	Methods chosen for preservation should allow easy portability to other or new system platforms.
	Components	Technical infrastructure has to be implemented and maintained
	Maintenance	Maintenance of systems both in the sense of keeping them operational and in keeping them up-to-date.
	Operation	Costs include people, material. Adequate and efficient software tools will minimize human intervention and accelerate processes.
	Flexibility	For maintenance over time and through changes in IT. Rapid change in IT requires flexibility in adaptation.
	Facilities	Location, security, safety, back-up (redundant storage).
	Class of preservation	Distinction can be made between preservation of bitstreams and of functionality (which includes bitstream preservation).
	Modularity	In the maintenance and replacement of (parts of) the infrastructure modularity may help to be cost-effective.
Law and policies	Legislation	Organizations and their business may be subject to specific legislation that needs to be accounted for.
	Policy	Each organization should have a preservation policy to enable consistent and cost-effective management. Regular monitoring of policies and activities is necessary.
Organization	Relationship building	Co-operation with other organizations may lower costs through synergies and economies-of-scale.
	Capacity building	Organizations should build the capacity for adequate preservation with respect to people, policies, practices, methods and technologies.
	Responsibilities	Clear identification and assignment of responsibilities help to avoid misunderstanding and failure of procedures and systems.

A possible approach in applying this model is as follows:

- identify business needs and scope of preservation (policy and risk questions);
- identify laws (regulatory environment);
- identify types of digital objects that will be created and need to be preserved (as well as how long they need to be preserved);
- identify consequences for people and the organisation; and
- identify methods, standards, tools, technologies and systems to be used.

Costs in Digital Preservation Policies

Cost is an important factor to consider when developing digital preservation policies; in fact, costs related to outsourcing, financial planning, technical infrastructure and staff training can weigh heavily on an institution's budget. Consequently, it is wise for an institution to undertake a cost-benefit analysis concerning its investment in digital preservation. However, it is widely accepted that, although the costs of preserving digital materials might be high, the costs, consequences and implications of not having a digital preservation policy may be higher and, in some cases, could affect the feasibility of preservation.

Table 7. ERPANET: Digital preservation policy costs.[17]

COSTS	Technical infrastructure	Equipment purchases, maintenance and upgrades
		Software/hardware obsolescence monitoring/review
		Network connectivity
	Financial plan	Strategy and methods
		Commitment to long-term funding
	Staffing infrastructure	Hiring training
		Ongoing training
	Outsourcing	

[17] Source: ERPANet (Electronic Resource Preservation and Access Network), "Erpaguidance: Digital Preservation Policy Tool," September 2003. Available at http://www.erpanet.org/guidance/docs/ERPANETPolicyTool.pdf.

Table 8. ERPANET: Business models of digital preservation.[18]

Make right economic choices	Identify which digital preservation opportunities should be pursued
	Justify choices within budgetary requirements
	Consider whether budgets can be expanded (if necessary), and if so how
	Consider short-term requirements as opposed to long-term requirements
Secure resources	Identify cost categories
	Identify cost centres
	Calculate costs
	Secure resources
Implement (Cost categories)	• Management • Services • Selection • Acquisition • Ingest • Cataloguing and Metadata creation • Processing • Documentation • Archiving • Access • User support • Technical co-ordination • Implementation
Mitigate costs	**Collaboration** (sharing the burden)
	Responsible stewardship (more active engagement in managing resources from more stakeholders to ensure that all parties are aware of their responsibilities)
	Services and Tools (provision and awareness of internally developed services and tools to external parties)
	Research (to help improve efficiency and effectiveness of digital preservation strategies and knowledge)

[18] Source: ERPANet (Electronic Resource Preservation and Access Network), "Erpaseminar: Business Models related to Digital Preservation, Amsterdam, 20-22 September 2004," Final Report. Available at http://www.erpanet.org/events/2004/amsterdam/Amsterdam_Report.pdf.

DPCC
Digital Preservation Cost Centers
(2006)

Digital preservation activities represent a new cost that is expected to be formidable. Because so little is known about the actual cost of digital preservation, this document identifies cost centres, but does not attempt to calculate the related expenses. Table 9, below, summarizes the key digital preservation functions, actions and cost impacts.

Table 9. DPCC: Functions, actions and cost impacts.[19]

FUNCTIONS	ACTIONS	COST IMPACTS
Planning	Creation, acquisition, evaluation and selection relating to preservation	Selection and evaluation costs are those associated with determining the desirability and feasibility of preserving the digital resource. Ideally, this process is first completed at the point of creation or acquisition and then again through time.
	Negotiation	These costs include the time required to negotiate the right to preserve resources as well as the rights management policies, i.e., who may access the resources, for how long and under what restrictions, if any.
	Determining and implementing the preservation strategy	Expenses may include the cost of software or hardware needed to prepare the digital resource for preservation and to make it available for access (e.g., the creation of emulation tools).
Storage	Data storage	These costs include expenses for the necessary technical infrastructure, i.e., hardware, operating systems, software, network, physical facility, etc. Data storage costs include one-time costs for the purchase of these components, licensing fees, maintenance charges, and recurring facilities and supply expenses. Charges related to replicated and backup copies of the data are also included here.
Administration	Data administration	Staff costs, as well as costs related to outreach of personnel using the preservation service. Expenses associated with following relevant developments and laws pertaining to digital preservation, conducting research and implementing development projects are also included here.
Ingest	Validation	Expenses associated with obtaining any necessary

[19] Source: Digital Preservation Committee (DPC), "Digital Preservation Cost Centers," October 2006. Available at http://www.library.yale.edu/iac/DPC/DigitalPreservationCostCentersFinal1.pdf.

		documentation and available metadata, the time spent checking the object received, machine validation and authentication of the digital resource.
	Data preparation	The expenses related to implementing the digital preservation strategy.
Data management	Content management	Costs, through time, associated with managing digital resources including activities such as format migration, digital resource deletion, re-validation and re-authentication.
Access	Resource discovery and retrieval	These are costs related to providing everything that is associated with reliably locating and accessing an acceptable presentation of the digital resource, e.g., the public interface, webserver, indexing, managing appropriate emulation tools, etc.
	Rights management	Expenses related to retaining rights and permissions information, implementing and administering services that manage access and use according to these rights.

LIFE/LIFE2
Lifecycle Information for E-Literature[20]
(2006-2007)

Both of the LIFE models are based on paper materials, and involve a methodology designed to capture, calculate and record the preservation costs in an object's lifecycle. The primary focus of these models is libraries. The LIFE/LIFE2 models identify cost centres by lifecycle stage. Work on these models produced two other key results. The first was an evaluation of what approaches are best suited in determining preservation costs. The conclusion was that a top-down audit was most appropriate for determining the costs of new repositories and the complete costs of existing repositories. The use of a bottom-up lifecycle was deemed most appropriate for determining the costs of a new content stream, evaluating content stream efficiency, comparing digital and analogue preservation, and assessing the impact of new tools or process changes. Both approaches were found equally useful in determining the running costs of a repository. The second result was the creation of a generic preservation model (GPM). The GPM focuses on determining the availability of tools, the development of tools and the complexity of formats. These additional products are indicative of a less focused research approach. The authors state that mapping a specific lifecycle can be complicated as it is not a straightforward process.

The cost centres identified in the LIFE2 model begin with the acquisition of material instead of the act of creation. Because this model focuses on paper-based objects, there is no

[20] See: http://www.life.ac.uk/.

need to consider creation as part of the lifecycle; however, to be applicable to digital preservation, the addition of this aspect would be required. The LIFE2 model does not attempt to calculate the expenses related to the cost centers it identifies, nor does it include an analysis of the benefits related to these costs. Without an analysis of these costs it is not possible to identify significant benefits, either direct or indirect. The one benefit that is mentioned by the authors is that the use of proper data management will prevent the need to re-create data later; however, there is no analysis of which cost this benefit would offset, it is simply mentioned in passing. The lack of analysis is significant since without it the adaptation of this model to digital preservation may not be possible without a complete reworking.

Table 10. LIFE/LIFE2: Identification of cost centres by lifecycle stage.[21]

Creation or Purchase	Acquisition	Ingest	Bit-stream Preservation	Content Preservation	Access
....	Selection	Quality Assurance	Repository Administration	Preservation Watch	Access Provision
....	Submission Agreement	Metadata	Storage Provision	Preservation Planning	Access Control
....	IPR & Licensing	Deposit	Refreshment	Preservation Action	User Support
....	Ordering & Invoicing	Holdings Update	Backup	Re-ingest	
....	Obtaining	Reference Linking	Inspection	Disposal	
....	Check-in				

Cost Models Analysis

Introductory Observation

The first thing to note in this analysis is that all the models described above relate to activities beyond the "purely" archival activities. Some of the models (e.g., KRDS, OAIS) were designed specifically for the preservation of scientific data. The authors of these models usually talk about

[21] Source: Richard Davies et al., "The LIFE[2] Final Project Report," LIFE Project: London, UK, August 2008. Available at http://discovery.ucl.ac.uk/11758/1/11758.pdf.

"Data Centres" as the repositories they have in mind, not "traditional" archives. ERPANET, although including scientific data in its scope, focused on the needs of museums to preserve cultural heritage objects. Other models, like LIFE, were designed for libraries and their specific needs of preserving *digitized* (rather than *born digital*) materials. This is again a function different from that of digital archives, which face challenges in preserving born digital records, not digitized books and other paper-based materials. Therefore, it is necessary to underscore in the very beginning of this analysis that none of the models described in this report fully address the needs of digital archives dealing with the preservation of *born digital records*. Although some issues and factors are common for the digital preservation processes, no matter what the nature of an object being preserved is, the existing knowledge base does not cater to digital archives specifically and the need for further research in this particular area is obvious.

Activities Models/Cost Centres/Cost Categories

The core element of almost every cost model presented here is an activities model, or cost centres/categories model, depending on the parlance chosen by the authors. No matter what the locution, they all refer to the same concept: identification of the key activities and operations that require money to be spent, thereby identifying the main areas to be watched to control the costs of digital preservation. The most elaborate activities models among those presented here are KRDS, OAIS, DPCC and LIFE. There is also a quite well-developed model of cost categories within the ERPANET's business models. The following table provides a comparison of these activities models, highlighting their similarities and differences. The KRDS model, which, at first glance, appears to be the most developed and detailed model, is used as a template.

Table 11. Activities comparison of the models identified in this report.

Activity	KRDS1/2	OAIS	DPCC	LIFE/LIFE2	ERPANET
Outreach	•				
Initiation	•				
Creation	•				
Acquisition	•		• [22]	•	•
Disposal	•				

[22] In the DPCC model there is no such distinctive phase as 'Acquisition'. However, the Planning stage includes Creation, Acquisition, Evaluation and Selection as functions within the stage. Therefore, it is agreed that Acquisition activity is applicable to DPCC.

Ingest	•	•	•	•	•
Archive Storage	•	•	•		
Preservation Planning	•	•	•	•[23]	•[24]
First Mover Innovation	•				
Data Management	•	•	•		•
Access	•	•	•	•	•[25]
Administration	•	•	•		
Common Services	•				•[26]
Estates	•				

This comparison of the models confirms that the KRDS model is the most detailed (possibly too detailed for most digital preservation projects). As described above, the KRDS model includes a "Pre-Active Phase," which refers to the creation and the initial use of data, before they are transferred to a data archives for preservation. Although the "Pre-Active Phase" is definitely important and sometimes even vital for the success of a preservation program, the preservation requirements must be kept in mind while creating and using data; to call these stages "cost activities" in respect of preservation is a definite stretch. All the costs encountered at this stage should be ascribed to data creation/usage costs, not to preservation costs. Therefore, it was decided that the Pre-Active phase should be excluded from the cost-benefit equation.

Another important observation suggested by the above table is that not all the basic activities are agreed upon by the various models. One of the most inconsistent models is the LIFE model. However, it is important to remember that the LIFE/LIFE2 models are based on an object's lifecycle and identify costs centres by lifecycle stage. Although there is no "archival

[23] In the LIFE/LIFE2 model the terms "Bit-stream Preservation" and "Content Preservation" are used at this stage, but since the KRDS model includes preservation action in the Preservation Planning activity, it is agreed that these phases of the two models correspond.
[24] Selection, Acquisition, Cataloguing and Metadata Creation, Processing, Documentation, Archiving, and Implementation categories are all included in this activity.
[25] This activity also includes User Support.
[26] This activity also includes Technical Coordination.

storage" lifecycle phase in these models, the costs associated with this phase could be included in the Bitstream Preservation activity as Repository Administration and Storage Provision. The same can be said about the Data Management and Administration activities, which are not specifically articulated in the LIFE model; components of these activities are present in different phases in the model.

Generic Cost Activities/Centres Model

There are areas where the different models coincide, and these areas are represented by the highlighted cells in Table 11, above. Most of the authors appear to agree with the inclusion of these activities in the overall "generic" cost centres model, which is presented in Table 12, below.

Table 12. Generic cost centres model: Activities and sub-activities.

ACTIVITIES	SUB-ACTIVITIES[27]
Acquisition	• Acquisition, evaluation and selection relating to preservation • Submission agreement • Ordering & invoicing • Depositor support
Ingest	• Receiving submission • Performing quality assurance • Generation of metadata and documentation • Reference linking • Validation • Deposit • Holdings update
Archive Storage	• Receiving data from ingest • Managing storage hierarchy • Replacing media • Disaster recovery • Error checking • Providing copies to access
Preservation Planning	• Monitoring of designated user community • Monitoring technology • Developing and implementing preservation strategies and standards • Developing packaging designs and migration plans
Preservation Action	• Generation of preservation metadata • Refreshment • Backup • Re-ingest • Inspection • Disposal

[27] The sub-activities are compiled from all the models involved.

Data Management	• Administering database • Performing queries • Generating reports • Receiving database updates • Loading new descriptive information • Loading new archive administrative data
Access	• Access provision • Access control • User support • Rights management
Administration and Services	• General management • Administrative support • IT support • Physical security • Utilities • Supplies inventory and logistics • Staff training and development

In this "generic" cost centres model, a conscious decision was made to split Preservation Planning and Preservation Action into separate activities, as it was felt that piling all the necessary steps for planning and actual preservation in one activity would make this area of the model too overloaded and cumbersome. Preservation proper is the core of what is discussed here and it deserves specific representation in the cost model. Another adjustment that was made concerns Common Services activities, which were deemed to be very close to, if not in fact a part of, Administrative activities. Accordingly, these two activities were merged into one: Administration and Services.

Cost Variables/Factors

Apart from the actual cost models, all of the studies examined offer a number of accompanying fundamentals that are very important for developing and implementing cost strategies. They bear different names—cost variables, or cost factors—but they all represent a common concept: coefficients that play essential roles in determining the costs of digital preservation. A detailed analysis of these components does not appear to be feasible, since these components are different for every given model and not enough details are provided for analysis. Nevertheless, a concise description of the components is included, due to their significance to the topic of the discussion. Table 13, below, presents a compilation of the factors mentioned in the models, divided into several large categories.

Table 13. Generic cost centres model: Cost factors by category.

CATEGORIES	FACTORS
Objects	• Influence on creation • Complexity • Preservation period • Number of depositors • Number, mode and frequency of deposits • Number, complexity and type of file formats • Number of versions and copies • Data volumes • Metadata, documentation, ethics and intellectual property rights (IPR) • Levels of processing, validation and calibration • De-accessioning costs • Management and refreshment • Storage media (capacity, costs) • Archive media monitoring • Number of users and user communities • Standard or custom interfaces • Level of user support • Access control • Number and volume of accesses • Access/distribution method • Service response times • Processed products
People	• Staff costs and labour rates • Skills • Quality • Training • Experience
Standards	• Standards
Practices	• Workflow • Operation • Processes • Activity duration • Outsourcing
Systems, Methods and Technologies	• Preservation method • Validation of methods • Sustainability • Portability • Components • Maintenance • Operation • Flexibility • Facilities

	• Class of preservation • Modularity • Levels of automation • Technical infrastructure (equipment, software/hardware, network)
Law and policies	• Legislation • Policy
Organisation	• Relationship building • Capacity building • Responsibilities
Financial plan	• Strategy and methods • Commitment to long-term funding • Budgetary requirements (short-term as opposed to long-term, and whether budgets can be expanded) • Cost categories • Cost centres • Calculate costs • Secure resources
Economic adjustments	• Inflation/deflation • Infrastructure costs • Cost of return for financing and investment
Costs mitigation	• Collaboration • Responsible stewardship • Services and tools • Research

Cost Benefits

A comprehensive analysis of the benefits of digital preservation is a project in itself. That being said, those models that identified benefits were fairly consistent on which ones they identified and the terminology they used in categorizing them. The benefits identified in the KRDS and OAIS models are nearly identical, which is not surprising since they have a parent-child-type relationship. The benefits are divided into six categories, which are not exclusive: Direct, Indirect, Near-term, Long-term, Private and Public. Benefits categorized as *direct benefits* have easily identifiable correlations to costs. These include new research, collaboration and fulfilling institutional mandates. The *indirect benefits* are often the ones that are accidental; consequently, they are something that needs careful consideration since, if they are not intended, there is a higher potential for them to be uncontrolled and unmonitored. They include costs that are avoided, such as not having to re-create data, the (re)use of records by new user communities and protecting earlier investments. All of these can be both near-term and long-term benefits; however, those benefits specifically designated by the models as near- and long-term are higher level benefits that are impacted by multiple cross-functional costs. The private and public benefits are significantly tied to the direct benefits, particularly those in the arena of research.

Taken as a whole, the categorization of benefits and the benefits identified are comprehensive; however, more work needs to be done to tie those benefits directly to the costs that create or impact them for a true cost-benefit analysis to occur. Although preservation does have a significant monetary cost, the preservation generates a cultural benefit that validates the expense, and the monetary consequences of not preserving outweigh the costs incurred.

Overview of Benefits

Action Item 32 from TEAM Canada Plenary Workshop #07 reads: "The Graduate Research Assistants assigned to General Study 16 [are] to develop a digital preservation cost-benefit template that identifies the various cost and benefit parameters or categories and that justifies why each of these is relevant to an organization's cost-benefit analysis of digital preservation." The cost portion of the proposed template was developed in the previous stage of this research, and therefore it was considered worthwhile to concentrate on the benefits aspect of the template. At the final stage of the project, the two templates should be reconciled to create a general cost-benefit template.

To build the benefit model of digital preservation, a comparison was made among the different existing models. This approach, which was used in the previous stage of the research, allowed us to search for similarities in the models and attempt to merge these approaches into one universal model.

In addition to a theoretical, academic approach to benefits, this report includes results of actual, practical work on digital preservation, as recommended by Action Item 33. The bulk of "actual" data has come from the results of other InterPARES 3 studies.

As noted in the previously-mentioned annotated bibliography, theoretical work on benefits is largely absent from the academic discussion regarding digital preservation. The only mention of benefits that was found in the source models was the *Benefits Taxonomy* included in KRDS1/2 ("Keeping Research Data Safe") model (see Table 4, above).

Unfortunately, the KRDS1/2 Benefits Taxonomy is the only well-developed and elaborate inventory of different benefits pertaining to the realm of digital preservation upon which a discussion of benefits can be based. The same problem—the lack of numerous and eloquent insights in digital preservation benefits—can be associated with practical, "actual" work on digital preservation. The sole InterPARES 3 TEAM Canada case study that discusses digital preservation in a way that makes it possible to "extract" a list of potential benefits is Case Study 08: North Vancouver Museum and Archives.[28] The model presented here was developed from the findings of Case Study 08, which demonstrates the different aspects of digital preservation, and the manner in which they can be significant in terms of benefits. The model is presented in Table 14, below.

[28] See: http://www.interpares.org/ip3/ip3_case_studies.cfm?team=1#cs08.

Table 14. Generic cost centres model.

Aspects of digital preservation	Significance in terms of benefits
Trusted custody/Security	Possibility to set up safety measures that will prevent unauthorized alteration of records, and will ensure the availability of the records over time
Digital nature of records	Allows for easier/automated organization and management of records, better availability of records, their migration to a safer environment/mode, and maintaining them over time
Technological properties of records	Different formats the records can be stored in allows for better flexibility in terms of preservation and access

As is demonstrated in the model, the general description of different aspects of digital preservation have been used and reworked to highlight possible benefits that can be derived from them. Ironically, benefits can be recognized in some areas that are traditionally identified as weak points of digital preservation, such as multiplicity of formats.

Benefit Template

These three aspects of digital preservation, which are relevant to benefits identification, will now assist in sorting through the numerous and verbose benefits presented in the KRDS model. It is likely that some kind of summarization of KRDS benefits would be helpful, for many of them are just different particulars of the same broader "benefit item." An attempt at reconciliation of the two tables is presented in Table 15, below.

Table 15. Reconciliation of the KRDS and Generic cost centres models.

Aspects of digital preservation	Related benefits
Trusted custody/Security	• Verification of information/records integrity • Lower future preservation costs • Protecting returns on earlier investments • Secure storage for information • Secures value to future users • Adds value over time as collection grows and develops critical mass
Digital nature of records	• New research opportunities • Facilitates easier availability and access to data • Allows for re-purposing and re-use of data • Increasing research productivity • Stimulating new networks/collaborations • Allows for knowledge transfer

	• Increasing productivity/economic growth • No re-creation of data • No loss of future research opportunities • Re-purposing data for new audiences • Re-purposing methodologies • Use by new audiences • Increased visibility of information included in records
Technological properties of records	• No data lost from records turnover • Short-term re-use of well curated data • Value to current users • Commercializing research

As mentioned, some of the listed benefits are facets of larger concepts. Moreover, the authors of KRDS model focus primarily on the preservation of scientific data, which is only one aspect of digital preservation; therefore they list quite a number of benefits that pertain only to specific needs of the scientific community. Some of these benefits were omitted from the model presented here due to their very narrow focus and some were re-worded to fulfill their broader purpose.

The area that focuses heavily on promoting the benefits of digital preservation is that which addresses the complications of digital records. The benefits of digital preservation should relate to the very digital character of its preservation. It is also necessary to point out that all the benefits of the third area (Technological properties of records) can be achieved only in case of properly handled issues that arose from the complexities of technology. For example, to make multiple file formats an asset rather than a drawback, the concerns surrounding multi-format matters must be adequately addressed and appropriately resolved.

Conclusion

Although the initial goal of this general study was to establish the benefits of digital preservation in terms of costs, most organizations or institutions have only encountered the initial costs of preservation project start-up. Therefore, only these costs were available for review. This does not allow for in-depth analysis of the data, greatly reduces the cogency of the study, and calls for more diverse and widespread search for relevant data in future undertakings on the subject. It is suggested that already implemented projects related to preservation of scientific data be included in the research based on the cost/benefits models discussed in the previous reports (e.g., KRDS). These models seem to be the most developed and usable cost analysis tools available at the moment.

The same reservations apply to the benefits part of this study. The available resources on benefits of digital preservation (or, rather, their lack) does not allow for a purely theoretical, academic research on the matter. The actual organizations that have digital preservation projects

ongoing should be carefully studied and analyzed in detail to derive the necessary information. The scope of this study did not allow for such in-depth research.

The review of the cost models presented above shows that, although some significant resources exist for assessing the costs of preservation, they still lack sufficient granularity for enabling accurate forecasts of the costs of digital preservation. Digital preservation programs require looking to the long term, and the defining of 'long term' is one of the aspects that archivists must identify. The most appropriate definition found was that of 'long term' being when changes in technology and users affect preservation and access. Another observation is that these models focus on scientific data, or cultural heritage objects, or e-literature, catering to data centres, museums and libraries. None of the models discuss archives of born digital records; it is this gap that needs to be filled. Additionally, there is a continuing need to better identify the correlation between the benefits and costs. Some of the models examined have fulfilled the first part of the challenge and have, in some cases, identified benefits. But for the most part, the models limit themselves to mere explanation of the types of costs a digital preserver may encounter, without much analysis of what the cost would be if no digital preservation is done. The cost-benefit analysis of digital preservation, which is still in its early stages of development, needs this kind of incentive to be calculated to push the process further; it needs to be expanded to different types of organizations, including those that are responsible for preserving digital records; and it needs to better delineate what costs can be expected relative to the benefits to be reaped.

Research Team

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Researchers:
Alexandra Allen, Project Coordinator, TEAM Canada
Luciana Duranti, Project Director, TEAM Canada

Graduate Research Assistants:
Joanna Hammerschmidt
Adam Jansen
Sergey Kovynev
Samantha Schmidt

Bibliography

Ashley, Kevin. "Digital Archive Costs: Facts and Fallacies." European Commission, Brussels, Belgium, 1999. Available at http://ec.europa.eu/archives/ISPO/dlm/fulltext/full_ashl_en.htm. Last accessed November 2011.

Beagrie, Neil, Julia Chruszcz, and Brian Lavoie. "Keeping Research Data Safe: A Cost Model and Guidance for UK Universities 2." JISC Final Report, April 2008. Available at http://www.jisc.ac.uk/media/documents/publications/keepingresearchdatasafe0408.pdf. Last accessed November 2013.

Beagrie, Neil, Brian Lavoie, and Matthew Woollard. "Keeping Research Data Safe 2." JISC Final Report, April 2010. Available at http://www.jisc.ac.uk/media/documents/publications/reports/2010/keepingresearchdatasafe2.pdf. Last accessed November 2013.

Becker, Christoph, et al. "Systematic planning for digital preservation: Evaluating potential strategies and building preservation plans." *International Journal on Digital Libraries (IJDL).* Vol. 10, No. 4 (December 2009). Available at http://www.springerlink.com/content/801685k478136425/. Last accessed November 2011.

Blue Ribbon Task Force on Sustainable Digital Preservation and Access. "Sustainable Economics for a Digital Planet: Ensuring Long-Term Access to Digital Information." *Final Report of the Blue Ribbon Task Force on Sustainable Digital Preservation and Access*, February 2010. Available at http://brtf.sdsc.edu/biblio/BRTF_Final_Report.pdf. Last accessed November 2011.

Bonn, Maria. "Benchmarking Conversion Costs: A Report from the Making of America IV Project." *RLG DigiNews,* Vol. 5, No. 5 (October 2001). Available at http://worldcat.org/arcviewer/1/OCC/2007/08/08/0000070513/viewer/file251.html#feature2. Last accessed November 2011.

Caplan, Priscilla. "Building a Digital Preservation Archive: Tales from the Front." *VINE: The Journal of Information and Knowledge Management Systems,* Vol. 34, no. 1 (2004). Available at http://www.fcla.edu/digitalArchive/pdfs/buildingDigitalPresentArchive.pdf. Last accessed November 2010.

Chapman, Steven. "Counting the Costs of Digital Preservation: Is Repository Storage Affordable?" *Journal of Digital Information,* Vol. 4, No. 2 (2004). Available at http://journals.tdl.org/jodi/article/view/100/99. Last accessed November 2011.

Charles Beagrie Ltd, JISC. "Keeping Research Data Safe Factsheet" Published September 2010. Available at http://www.beagrie.com/KRDS_Factsheet_0910.pdf. Last accessed November 2011.

The Commission on Preservation and Access, and The Research Libraries Group. "Preserving Digital Information: Report of the Task Force on Archiving of Digital Information." May 1996. Available at http://www.oclc.org/research/activities/past/rlg/digpresstudy/final-report.pdf. Last accessed November 2011.

Consultative Committee for Space Data Systems. "Reference Model for an Open Archival Information System (OAIS): Recommendation for Space Data System Standards." CCSDS 650.0-B-1, *Blue Book,*

Issue 1 (January 2002). Available at http://public.ccsds.org/publications/archive/650x0b1.pdf. Last accessed November 2013.

Currall, James, Peter McKinney, and Claire Johnson. "Digital Preservation as an Albatross." IS&T Archiving 2006 conference, Ottawa (May 2006). Available at https://dspace.gla.ac.uk/bitstream/1905/535/1/espida_jcpmcj_albatross.pdf. Last accessed November 2011.

Davies, Richard, et al. "The LIFE^2 Final Project Report." LIFE Project: London, UK, August 2008. Available at http://eprints.ucl.ac.uk/11758/1/11758.pdf. Last accessed November 2013.

Dawes, Sharon S., et al. "Making Smart IT Choices: Understanding Value and Risk in Government IT Investments." University at Albany/SUNY, Center for Technology in Government, April 2004. Available at http://www.ctg.albany.edu/publications/guides/smartit2/smartit2.pdf. Last accessed November 2011.

Digital Preservation Committee (DPC). "Digital Preservation Cost Centers." October 2006. Available at http://www.library.yale.edu/iac/DPC/DigitalPreservationCostCentersFinal1.pdf. Last accessed November 2013.

Digital Preservation Coalition (DPC). "Report for the DCC/DPC Workshop on Cost Models for preserving digital assets." York, UK, July 2005. Available at http://www.dpconline.org/events/previous-events/137-cost-models. Last accessed November 2011.

Digital Preservation Committee. "Digital Preservation Cost Centers." October 2006. Available at http://www.library.yale.edu/iac/DPC/DigitalPreservationCostCentersFinal1.pdf. Last accessed November 2011.

ERPANet (Electronic Resource Preservation and Access Network). "Erpaguidance: Cost Orientation Tool." Information Society Technologies, September 2003. Available at http://www.erpanet.org/guidance/docs/ERPANETCostingTool.pdf. Last accessed November 2013.

ERPANet (Electronic Resource Preservation and Access Network). "Erpaguidance: Digital Preservation Policy Tool." September 2003. Available at http://www.erpanet.org/guidance/docs/ERPANETPolicyTool.pdf. Last accessed November 2013.

ERPANet (Electronic Resource Preservation and Access Network). "Erpaseminar: Business Models Related to Digital Preservation, Amsterdam, 20-22 September 2004." Final Report. Available at http://www.erpanet.org/events/2004/amsterdam/Amsterdam_Report.pdf. Last accessed November 2013.

Feeney, Mary, ed. "Digital Culture: Maximising the Nation's Investment: a Synthesis of JISC/NPO Studies on the Preservation of Electronic Materials." National Preservation Office, UK, 1999. Available at http://www.ukoln.ac.uk/services/elib/papers/other/jisc-npo-dig/. Last accessed November 2011.

Fox, Peter. "Archiving of electronic publications: Some thoughts on cost." *Learned Publishing,* Vol. 15, No. 1 (January 2002).

Hendley, Tony. "Comparison of Methods and Costs of Digital Preservation." British Library Research and Innovation Centre, 1998. Available at http://www.ukoln.ac.uk/services/elib/papers/tavistock/hendley/hendley.html. Last accessed November 2011.

Kingma, Bruce R. "The Costs of Print, Fiche, and Digital Access: The Early Canadiana Online Project." *D-Lib Magazine* Vol. 6, No. 2 (February 2000). Available at http://www.dlib.org/dlib/february00/kingma/02kingma.html . Last accessed November 2011.

Lavoie, Brian F. "The Incentives to Preserve Digital Materials: Roles, Scenarios, and Economic Decision-Making." OCLC Online Computer Library Center, Dublin, Ohio, April 2003. Available at http://www.oclc.org/research/activities/past/orprojects/digipres/incentives-dp.pdf. Last accessed November 2011.

Oltmans, Erik and Nanda Kol. "A Comparison Between Migration and Emulation in Terms of Costs." *RLG DigiNews,* Vol. 9, No. 2 (April 2005). Available at http://worldcat.org/arcviewer/1/OCC/2007/07/10/0000068902/viewer/file1.html. Last accessed November 2011.

Palm, Jonas. "The Digital Black Hole." Part of the Training for Audiovisual Preservation in Europe (TAPE) program, April 2005. Available at http://www.tape-online.net/docs/Palm_Black_Hole.pdf. Last accessed November 2011.

Russell, Kelly, and Ellis Weinberger. "Cost Elements of Digital Preservation." UK Web Archive, May 2003. Available at http://www.webarchive.org.uk/wayback/archive/20050410120000/http://www.leeds.ac.uk/cedars/colman/CIW01r.html. Last accessed November 2011.

Saffady, William. "Cost Analysis Concepts and Methods for Records Management Projects." ARMA International, 1998.

Sanett, Shelby. "Toward Developing a Framework of Cost Elements for Preserving Authentic Electronic Records into Perpetuity." *College and Research Libraries,* Vol. 63, No. 5 (September 2002). Available at http://crl.acrl.org/content/63/5/388.full.pdf. Last accessed November 2011.

Strodl, Stephan, et al. "How to Choose a Digital Preservation Strategy: Evaluating a Preservation Planning Procedure." Proceedings of the ACM IEEE Joint Conference on Digital Libraries (JCDL'07), Vancouver, British Columbia, Canada, June 18-23, 2007. Available at http://www.ifs.tuwien.ac.at/~strodl/paper/FP060-strodl.pdf. Last accessed November 2011.

Wheatley, Paul. "Costing the Digital Preservation Lifecycle More Effectively." Proceedings of the iPRES 2008 (The Fifth International Conference on Preservation of Digital Objects), September 2008. Available at http://www.bl.uk/ipres2008/presentations_day1/19_Wheatley.pdf. Last accessed November 2011.

Wright, Richard, Ant Miller, and Matthew Addis. "The Significance of Storage in the "Cost of Risk" of Digital Preservation." *The International Journal of Digital Curation,* Issue 3, Vol. 4 (December 2009). Available at http://www.ijdc.net/index.php/ijdc/article/viewFile/138/173.