The LIFE project research review
Mapping the landscape, riding a life cycle

James Watson. November 2005.
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Contents

1) Abstract

The LIFE project research review investigates both life cycle costing and digital preservation, with a view to creating a useable life cycle costing model that can be applied to digital preservation within an HE/FE environment.

The general concept of life cycle costing (LCC) is explored as a cost management tool. LCC is concerned with all stages of a life cycle, from inception to retirement. "Life cycles" are used in many arenas; this broader context is also taken into account.

Although not a vast amount of study has been done in this domain, specific library-based life cycle collection models are considered. These provide useful costing models, including the first application of a costing model for digital collections.

Research concerning the effective management and preservation of digital materials is looked at, some of which notably endorses a life cycle approach. This line of investigation provided the most significant perspective for digital preservation life cycle costing.

Records management is also discussed, insofar as records management principles have been advocated for digital information management and preservation. It thus provides further insight and has informed work in the area of life cycle management.

To fully appreciate the life cycle costs associated with digital preservation it was necessary to have a reliable framework of digital preservation costs. Literature involving the precise nature of stages involved in digital preservation was examined to ensure that all the relevant cost factors were taken into account.

Furthermore, it was significant to address the question of who is responsible for carrying out this work and how this should be done.

Life cycles (including life cycle costs)

2) Introduction

The first phase of LIFE was composed of a literature review and desk research; the coverage of the review was designed to reflect the extent and aims of the LIFE project. The purpose of the review was to give the project as much information as possible on which to base its life cycle model. This report is the result of this phase of the project.

Specifically the review covered: life cycles in libraries, life cycle costings in libraries, life cycles in the preservation and management of digital information, costing models in libraries, costing models for digital preservation and roles and responsibilities within digital preservation. There were also smaller amounts of work done into the background of the information life cycle and life cycle costing more generally. The sections and structure of this report reflect these broad stages.

The most comprehensive areas in the review were life cycles in libraries, life cycle costings in libraries and life cycles in the context of digital preservation. This reflects the focus of the LIFE project.

The research review is based around the objectives of LIFE and, as such, considers the costing and life cycle models in this review in those terms

3) General life cycle costing

The literature review began with an overview of life cycle costing.

Life cycle costing was created in the 1970's to consider the ownership as well as the acquisition costs of military systems, and to compare costs over their life cycles.

LCC is concerned with all costs associated from inception to retirement. **Cost management** is a way identifying all the costs associated and making informed choices throughout the life cycle.

Fundamental concepts common to all applications of LCC:
cost breakdown structure
cost estimating
discounting
inflation

Problems for LCC include: estimating costs – determining initial costs is not difficult compared with the estimation of direct and indirect maintenance and operation costs; many external factors can be almost impossible to predict

Prediction errors – measurement errors (differences in measurement units) and sampling errors (a sample may not be representative) or errors in assumptions can all adversely affect results

With a reference from a seminal paper in the arena of library life cycle costing **(Stephens, 1988)** (below), the review began with what seemed like an apposite place: an early UK recommendation for the concept of life cycle costing: the Terotechnology handbook, published by the Committee for Terotechnology of the British Department of Industry in 1978 (terotechnology: "The branch of technology and engineering concerned with the installation, maintenance, and replacement of industrial plant and equipment and with related subjects and practices" taken from http://www.oed.com/ on 22/7/2005).

Great Britain. Committee for Terotechnology (1978)
The report advocates the life cycle costing approach and provides case studies on a selection of physical assets, including: a GLC Office Block, the National Bus Company and Rank Xerox.

Although the life cycle methodology proposed is too rooted in the specific physical assets under discussion, to be used by LIFE, the paper provides an excellent insight into life cycle costing and its value within the management of all assets.

"Few organisations fail to attempt an assessment of the cost of a capital investment. Life-cycle costing, however, goes further by emphasising the life-cycle benefits and commitment to meeting the cost of supporting physical assets. Life-cycle costing provides a framework for weighing both acquisition costs and whole life support costs, by quantifying and appraising all cost elements which provides the best value for money"(p 40)

The life cycle stages of physical assets are defined by the report as:
Acquisition (of physical assets)
- Specification phase
  - The cost effectiveness of the asset's characteristics (performance, reliability, safety and perhaps non-material features such as appearance)
  - Cost effectiveness of individual components and sub-systems and their contribution to the value of the physical asset as a whole
  - The cost effectiveness of all cost elements of each phase over the life-span of the physical asset
- Sale and purchase phase
- (also mentions: acquisition, installation and commissioning, operations and maintenance, maintainability, reliability, availability and downtime, disposal)

The operational life (of physical assets)
- Maintenance
- Operational management of physical assets

Disposal of physical assets

It is interesting that, what developed as a technique for the costing of physical assets, was developed to cost the stewardship of physical collections in a library environment, and is now being adapted to cost the stewardship of digital (in a way: non-physical) assets in a library environment.

The literature covering general life cycle costing is rich, see for example: **Kirk (1983, 1995)** for further information.

4) Further life cycle background

The review was cast wider with research into the broader context of the concept of "life cycles". Accordingly, LIFE considered models including:

- Construction (Building and Maintenance) Life Cycle
  - Cost Analysis
  - Cost Design
  - Cost Impact
- Family Life Cycle
- Information (Resources) Life Cycle
- Information System Life Cycle
- Information Technology Life Cycle
- Organisational Life Cycle
- Plant Life Cycle
- Records Life Cycle
- Software Development Life Cycle
- Waste Management Life Cycle

Although, similarly to the terotechnology handbook, some models did strike chords with LIFE, no models were as appropriate for the project as an amalgam of the life cycle management of digital material and life cycle collection management as defined by Shenton etc.

More general searches on life cycles with general application in libraries did not reveal very much. There was some information on the application of certain life cycle models (although not generally costing) to help with some management activities. Including:
Cheatham (1985); Cummins, Jenks (1988) and Gupta, Chin (1991).

McGinn (1993)
McGinn's article is typical of the types of application that life cycle techniques have found in libraries. He uses the product development life cycle to help to provide insight into public library reference services. The product life cycle proceeds through an "s" shaped curve of sales volume, with the stages of Introduction, Growth, Maturity and Decline.
McGinn urges reference services to make sure their products (i.e. reference services etc) remain as close to the top of the growth curve as possible.

Dugan (2002)
Robert Dugan advocates the software (information) life cycle, as mentioned above, and applies it broadly to the library context to extract IT costs.

Although the focus of his discussion is IT hardware and software infrastructure, Dugan does mention that his methodology can also be applied to information resources:
"The cost model is applied to hardware, software information resources…" (p 239)
The stages he defines are generic enough to be widely applied:
Investigation
Negotiation

Acquisition
Installation
Training
Maintenance
Evaluation
Upgrade, Migrate, Replace or Abandon

In summing up the article, Dugan also makes some telling points:
“Application and consideration of these benchmarks may be invaluable when confronting future costs pressures, such as creating and maintaining digital libraries” (p 243)
and
“The more a library administrator understands the details of initial and recurring costs for the application within the life cycle of applied information technologies, the more effectively the budget will be prepared” (p 243)

The extract above demonstrates the general application of these techniques, an exercise in costing IT infrastructure is advocated here for information resources (collections).

Although these sorts of applications are too generic to be suitable for LIFE, the exercises do have a certain synchronicity with the aims of the project in that, essentially, they apply a life cycle “tool” to library functions.

These general resources on life cycle costing provided an excellent insight into the background of the concept of LCC. As these techniques provide the background to studies such as Stephens and Shenton (see below), and these studies in turn are the predecessors of the LIFE project, this research undoubtedly provides useful background information for the project.

5) Library based life cycle collection models

The corpus of work on life cycle costing within a library environment (and its extension to life cycle collection management) is not vast; however, the work is important as it provides one of the bases LIFE.

There is a clear progression in the literature surrounding life cycle costing and collection management in libraries. One can see movement through Stephens to Shenton with parallel developments in the US with King, Montgomery and Sanett.

Stephens (1988)

The application of life cycle costing techniques to library collections began with Andy Stephens of the British Library in 1988. He introduces the formula for working out the total cost of keeping an item in a library throughout its life. The system is discussed and advocated, but, in this early study, no figures are applied. Formulas are defined for monographs and for serials, with the persistent effort for receiving and processing each issue of a serial causing the differences in the formula:

monographs:
K(t)=s+l+a+c+pl+p(t)+ht
serials:
K(t)=s+lt+c+at+plt+hlt+p(t?)+ht?

Where:
s is the cost of selection
l is the literature cost
lt is the cost of subscription for t years
a is the accession acquisition and processing cost
c is the record creation cost

pl is the initial preservation cost
at is cost of accessioning t years' issues
p(t) is the depreciated long-term preservation cost to be incurred during the period t
plt is the cost of preserving t years' issues
hlt is the first handling cost for t years' issues
ht= the storage cost, which is linearly related to t
p(t?)= the likely preservation cost to be incurred by each issue during the period t
ht?= the storage cost for each of the issues received during the period t

(n.b.: t?= termial i.e. 1+2+3…+t)
(pp 139-140)

These formulae are noteworthy because they provide the first example of this sort of costing model. They are obviously (and necessarily) designed for the print library world, but they are still generic enough to be applied at a high level to all library materials. It is also interesting to note, at this early stage, the differences in the models according to the format – monographs or serials, and the differences in the life cycle costing that this will make.

Although the stages will differ, this approach reflects exactly the approach that the LIFE project will undertake. The formulaic layout of the costing methodology provides a valuable precedent for the life cycle approach to electronic collections.

One of Stephens's concluding comments rings in the ears of the stewards of collections in the mid 2000's:
"By using the technique, the librarian should have an objective and realistic means of achieving a balance in allocating resources to functional activities" (p 138). Like much of this paper, this statement is as important to the management of digital resources as it is to the management of print.

Hernon (1994)
Hernon's article is an early discussion of the "information life cycle" in the context of managing US governmental information. Although it is not strictly library based, its application of the life cycle model to information resources is relevant.

Interestingly, and similarly to the approach of LIFE, Hernon informs his work by exploring the types of life cycles which exist, listing construction projects, family life cycle, information (resources) life cycle, information system life cycle, information technology life cycle, organizational life cycle, plant life cycle, product life cycle, records life cycle, software development life cycle, waste management life cycle and so on.

The report provides a review of the context of US government information (for example: the Paper Reduction Act of 1980), and then continues to provide a synopsis of the US information policy instruments and their take on life cycles. These stages are "regrouped" by Hernon to provide specific, generic stages, namely:
Information Creation and Gathering
Production, Processing and Publication
Transmittal (Access, Dissemination and Distribution)
Retrieval and use
Retention (Storage and Archiving) and Disposition

Hernon comments:
"The activities of all stages of the life cycle are interrelated, and the decisions made prior to the first stage (and during that stage) influence the 'options and outcomes of later stages';" p 166

Although the life cycle stages that the report enumerates are not suitable for the LIFE project, he provides an excellent (and foresighted) application of broad life cycle principles to information (resource) processing in an electronic environment.

Stephens (1994)
In his second report on life cycle costing in libraries management Stephens builds on his previous work and uses practical case studies to input data into his model. The application of financial information into a set life cycle model provides the archetypal life cycle costing methodology.

The exercise finds that the costs for keeping monographs for 25 years in the Document Supply Centre are £36.94, whereas reference material costs £64.59; the costs for keeping serials are £2173.12 and £3107.50 respectively.

Stephens's case studies reveal several noteworthy factors: firstly, he considers the same format of items (i.e. monographs and serials) in different management situations (document supply and reference) and finds that the costs vary because of the differing management, access and storage considerations. This analysis of the difference that management processes, format of material and the purpose of the collections makes to the cost of its life cycle is a relevant metric to LIFE. Secondly, it is symptomatic of the difficulties of preservation, whether traditional or digital, that Stephens makes the comment:
"The cost of long term preservation *(p(t))* and *(pt(?))* was omitted from the table of results because of the wide range of preservation options available, and the likelihood that cheaper, alternative methods of treatment might become available in the medium term" (p 134)

Writing in 1994 Stephens states:
"The scale of the British Library's commitment to collection management is considerable. Its collections already occupy over 370 miles of shelving, with a growth rate of seven miles per annum" (p 130)
as noted above, the parallels between the environment described here, and that in which we find ourselves in 2005, is remarkable.

Montgomery, Sparks (2000)
The body of work to come from Carol Hansen Montgomery (and her associates) at the WW Hagerty Library of Drexel University is valuable in providing comprehensive practical analysis of the management of journals, in print and electronic formats.

Montgomery's earliest study provides an enumeration of the cost elements of the management of journals, in an academic library environment.

Although the stages within the Montgomery's management process are not explicitly defined as a life cycle, there is discussion of a life cycle cost analysis approach in the paper, and some of the stages could certainly be considered as a life cycle:

Circulation/Access
- Re-shelving
- Stack maintenance
- User photocopying
- Collecting use data

Reserve
- Article file maintenance
- Article checkout
- Maintaining e-reserves

Technical Services
- Print journal check-in
- E-journal acquisitions
- Claiming

- Binding
- Cataloging print
- Cataloging e-journals
- Catalog/e-journal list maintenance
- Print subscriptions
- Electronic subscriptions

Information Services
- Reference at desk
- Instruction/Promotion
- Preparing documentation
- Journal selection

Document Delivery
- Faculty copy service
- Interlibrary loan - Borrowing

Systems
- Infrastructure purchase
- Infrastructure maintenance
- Negotiating contracts
- Setting up access
- Developing decision
- support tools
- Collecting use data
- Printing

Space Utilization
- Occupying space

Administration
- Managing the change
- Attention to decisions
- Budgeting

As well as this breakdown of cost elements, the article provides some solid figures on how much the print and electronic journals cost to manage

Montgomery has provided valuable updates on the work and methodology provided in this paper in **Montgomery (2000)** and **Montgomery (2002).**

Deegan (2001)
Deegan gives a brief introduction to the concepts of life cycle management of digital library collections. Building on the work of Beagrie and Greenstein (below), she advocates life cycle management for success.

Speaking specifically of digitization, Deegan isolates the following stages:
assessment and selection
grant writing and fund raising
feasibility testing
costing and piloting
copyright clearance and rights management
preparation of materials
benchmarking
digital capture
quality assessment

Deegan also, rightly, asserts that:
“Digital data needs much more active, interventionist methods of preservation from a much earlier stage in its lifecycle than analogue” (p 407).

Deegan's article re-iterates concepts discussed in the book she wrote with Simon Tanner Digital Futures: Strategies for the Information Age.

This paper provides an early translation of the specifically digital recommendations for life cycle management to an explicitly library environment.

Lawrence, Connaway, Brigham (2001)

The paper provides a literature review and an exploration of available methodologies for library costing exercises.

From the literature, the paper identifies what can be thought of as two costing methods three costing analyses.

The models are cost analysis studies and cost distribution and allocation studies. Where cost analysis studies take a bottom up approach to analysing the tasks involved with a job, assigning times and developing costs accordingly. And where cost distribution and allocation studies are top-down methods which look at total actual expenditures which are allocated to various cost centres. The LIFE project will aim to use both methods, with comparison between the levels to provide as good a costing as possible.

The three methods of analysis that are outlined are: unit costing and timing, cost-effectiveness and cost benefit measures.

Cost categories are allocated as follows:
Purchase cost of holdings
Operating expenses
Wages and salaries
Building and facilities
Fixtures and equipment

With the costs of the first three categories being obtained from direct surveys of ARL institutions and the costs of the latter three being estimated and estimated external industry data.

The study uses a cost allocation approach to obtaining figures. Interestingly, it uses a very innovative methodology for allocating costs:
"The principle allocation method used was the physical area occupied by various types of holdings. The area storage requirements of the various media were used to calculate a 'book equivalent' for each media type that represents the fraction of space required by the media type relative to books and manuscripts."
This approach has been adopted on the basis that:
"The research confirms that the space consumed by a collection is an excellent first-order proxy for the costs associated with maintaining and circulating the collection. For example, a collection the occupies twice the space of another collection will generally require twice the labour and twice the assets (shelving tables etc) and incur twice the expenses" p545

Life cycle costs were obtained by combining the purchase price with a discounted annual price.

This paper applies a genuinely innovative methodology to the concept of life cycle costing. This innovative approach to applying cost metrics will certainly influence LIFE.

The study also produced a spreadsheet tool, the: "Library Interactive Costing Spreadsheet" based on the study. One of the few spreadsheet based costing tools that this research discovered.

Connoway, Lawrence (2003)

This D-Lib article reports the findings of a study in which 11 ARL (Association of Research Libraries) librarians were asked to think of a scenario comprising of a totally print or totally electronic library and identify costs therein.

The idea of the paper: “is primarily to compare the life-cycle costs of ownership between print materials and electronic materials” (p 2). The life cycle stages below were constructed in consultation with the librarians and costs were estimated across the defined stages. The stages were then divided by the ‘consultant’ librarians between resources used: labour, space, materials and equipment, to obtain an accurate cost.

The stages were defined as:

Selection
- Jobber list maintenance
- Review jobber submissions
- Patron request
- Bibliographer recommendation
- Receive gift

Acquisition
- Purchase monograph
- Receive
- Process gift
- Ship returns

Cataloging
- Authority control
- Catalog
- Classify
- Maintain database

Maintenance
- Bind
- Mark
- Secure
- Bar code
- De-acidification
- Mend and repair

Circulation
- Shelve / reshelve
- Store in stacks
- Checkout
- Convert
- Trace
- Recall
- Overdue
- Return
- Process lost book
- Issue fines notice
- Collect fines
- Reading / viewing areas

Warehousing / storage
- Identify
- Update database
- Mark
- Move
- Store
- Retrieve / return

Deselection
- Identify

Update database
Retrieve
Pack
Ship
Dispose

Again, as has been observed before, although these processes are not defined as life cycle stages in this paper, they are similar to the life cycle concept as referred to in the LIFE project.

The paper concludes that labour, aggregate space requirements and material resources will be less in a digital environment.

The report provides an interesting variation on life cycle costing. The splitting of the costs of the life cycle stages between the type of resource is innovative.

King, Boyce, Montgomery, Tenopir (2003)
This paper defines a framework of economic "metrics" to gather information about the performance of library services. These metrics are defined as: inputs, outputs, usage, outcomes and domain. There are also "derived metrics" which are defined: performance, effectiveness, cost-effectiveness, impact and cost benefit.

The metrics are then assigned perspectives which define where the measurement (hence, "measurement perspectives") of the metric is felt; these perspectives vary considerably from the value derived by the community served to the cost of the resource as borne by the library.

There is also a discussion of the "value" that information resources can provide, with the difference defined between exchange value (what is paid for information both in time and purchase price) and use value (the benefits of having used the information).

There are two types of metrics defined: specifics, consisting of: inputs (resources), outputs (products and services), usage (use and non-use), outcomes (consequences of information); and domain; and derived, consisting of: performance, effectiveness, cost effectiveness, impact and cost benefit.

The paper describes how data was input into these metrics; specifically, the framework is applied to the print and electronic journals collections at five different institutions.

The report concludes by assigning benefits or cost (including non-financial detriments) to a series of measurements within the metric framework.

The report finds that:
"electronic collections and services will yield benefits in requiring lower prices per title, less time of staff, and, potentially, substantial savings in space" (p 397).

Although the approach taken to defining metrics is thorough and very useful, it is slightly different to the philosophy of LIFE. The report does, nevertheless, provide an excellent analysis of different types of value and metric which measure benefit or detriment in a variety of ways.

Shenton (2003)
After its first extension in Stephens' second paper, a second development was made to Stephens' methodology by Shenton in 2002.

The concept of "life cycle collection management" is established and then defined as one of the British Library's strategic "strands".

Shenton's life cycle collection management exercise adopts the following methodology:

"…the initial phase concentrated on that part of the British Library's collections that currently form the printed archive…Having defined the phases that comprise the life cycle, … An internal data gathering exercise was undertaken using the Library's finance system in conjunction with performance information" (p 259).

Monograph life cycle costs:
K(t)=s+a+c+pl+hl+p(t)+cs(t)+r(t)
Serial life cycle costs:
K(t)= s+at+c+plt+hlt+p(t?)+cst?+rt?

Where
K(t) is the life cycle cost
s is the selection cost
a is the acquisition processing cost (excluding the purchase price)
c is the cataloguing cost
pl is the initial preservation cost (such as an archival enclosure)
hl is the initial handling cost (including pressmarking, labelling and placing)
p(t) is the likely preservation cost over time (including interventive conservation)
cs(t) is the collection storage cost over time
r(t) is the likely retrieval and replacement cost over time

There is a notable extension to Stephens' methodology as Shenton does obtain a practical cost for preservation: "General preservation – interventive conservation including rebinding". These activities are defined areas within more general preservation and, as such, they provide a useful example of how costs that can appear difficult to quantify can be assigned values. This method of costing preservation illustrates the paradigms that these exercises have with digital collections as does Stephens's omission of preservation from his model (see above).

The methodology also has another notable development in extracting the varying cost through the life cycle of a collection. This is manifested by extracting the varying, relative proportions of resource expended across the stages, in year 1, year 10 and year 100 of the collection.

The application of the model below to the British Library's "Digitised Masters" is perhaps the first life cycle costing of digital collections. The exercise is valuable for informing future work.

Digitised Masters
K(t)=s+ipr+cons+r+cap+q+m+acs(t)+p(t)

ipr= the cost of checking the ipr (intellectual property rights)
cons= is the conservation check and remedial conservation costs
r= the retrieval and reshelving costs
cap= the capture of the digitised master
q= is the cost of quality assurance of digitised master and production of service copies
m= the metadata creation cost
acs(t)= the access cost over time
p(t)= the preservation and storage costs over time

This model is an excellent example of the development of an electronic life cycle. It can be observed that the stages within the formula have been altered to suit the specific management processes surrounding the work.

The assertion remains, that:
"Storage, preservation and access costs were difficult to determine. In particular, their long-term cost implications could not be determined" (p 266)

but, nevertheless, this is a groundbreaking cost model. Shenton's definition of the digital life cycle (or e-life cycle as she puts it) is a high level, strategic model and the first of its kind defined. A tool set in these terms will be used by the LIFE project.

The model provides the first example of a life cycle costing model with a consideration for preservation. The LIFE project will aim to synthesise a similar tool to provide a generic management and costing tool for digital collections.

Schonfeld, King, Okerson, Fenton (2004)
The life cycle model that Schonfeld et al's research report for the CLIR proposes is close to the ethos of LIFE.

The report begins with an overview of current activity and a literature review. As the title suggests, the report focuses on periodicals. Data was used from eleven academic libraries, incorporating two sets of information from existing studies and mining data from a further nine institutions.

Data was collected around 66 categories, which are broadly analogous to this report's definition of life cycle stages. These activities are reproduced in appendix C.

The article proposes an inventory of cost stages, which, together with the categories above, form the life cycle of the digital resource. The stages demonstrate a strong insight into the management of electronic resources. The differentiation between costs that are one time in nature, that are recurring, that are principally one time but do recur, and those that vary as to the amount of usage, is an alternative way of expressing Shenton's relative spends over specific years of the life cycle of the collection item.

There is a formula defined for the total life cycle costs of having an item in the collection.

There is a necessary and unavoidable limitation in the report:
"There is as yet no archiving solution for electronic periodicals, so it is not possible to calculate the costs or determine how they will be borne."[p 2]

The life cycle costing formula is defined as:
Print
One year:
All staff costs on the current issue format
Staff costs for those activities on the backfile format that are one-time in nature, namely:
- Collection development
- Licensing and negotiation
- Subscription processing, routine renewal and termination
- Receipt and check in
- Routing of issues and/or TOC
- Cataloguing
- Linking services
- Physical processing

Depreciation of staff workstations, allocated on the same basis as the staff costs
Total cost of binding
Total cost of subscription agents
Cost of space occupied by the current issues reading room during the year

Ongoing
Staff costs on the backfile format for ongoing services, calculated on a dollar-per-year basis, namely:
- Stacks maintenance
- Circulation

Reference and research
User instruction
Preservation
Other activities

Depreciation of staff workstations, allocated on the same basis as the staff costs
Depreciation of publicly available workstations, allocated at 2% to print periodicals
Annual cost of storage space in an off campus facility, calculated on a dollar-per-year basis
Annual cost of shelving, calculated on a dollar-per-year basis

Therefore: the print life cycle cost= 1*(One time cost per title) + Net present value of 25 years of [(Bindings per title)*(Annual ongoing cost per volume)]

Electronic:
One year:
Staff costs for those activities that are effectively one-time in nature, namely:

Collections development
Receipt and check in
Cataloguing
Linking services

An allocation of staff time costs for two activities that are principally (we estimate 75%) one-time in nature but have recurring components to them as well

75% of negotiating and licensing
75% of preservation processing

The depreciation of staff workstations, allocated on the same basis as the staff costs

Recurring (that don't vary by usage):
Staff costs for those activities on the electronic format that are effectively recurring, unrelated to usage, in nature:

Routing
Preservation
Other activities

An allocation of staff costs for two activities that are principally (we estimate 25%) one-time in nature but have recurring components to them as well:

25% of negotiations and licensing
25% of subscriptions processing

Depreciation of staff workstations, allocated on the same basis as the staff costs

Some costs vary as the amount of usage:
Staff costs for those activities on the electronic format that are effectively recurring, related to usage, namely

Circulation
Reference and research
User interaction

The depreciation of staff workstations, allocated on the same basis as the staff costs
The depreciation of publicly available workstations, allocated at 6% to electronic periodicals

Therefore: Electronic Life-Cycle cost= 1*(One time cost per title)+ Net present value of 25 years of (Annual ongoing cost per title)+1.21* use related cost per title)

[It's 1.21 because: "Recent surveys in three universities suggest that there is only about 21% more use beyond the five years"]

The differences between the print life cycle stages and the electronic life cycle stages are illuminating, as are the estimates of the ongoing and recurring costs.

The approach of this report which defines a “generic” life cycle, with stages which are included or excluded as necessary, is novel, and one which the LIFE project will also adopt. For example in stage 13, preservation, of the data collection instruments, the following stages are defined:
Preservation
Conservation and repair
Preservation microfilming
All preservation and archiving associated with electronic periodicals
Disaster recovery planning and activities
it is obvious which stages will be relevant to print or electronic formats. This approach allows one tool to be applicable to multiple collections of varying formats.

This report provides a practice based definition of a life cycle, which can be applied to multiple collections. It is a valuable addition to the literature.

The article in D-Lib **(Schonfeld et al, 2004)** provides another analysis of the results presented in this report.

King, Aerni, Brody, Herbison, Kohberger (2004)
King et al report on the costs of the electronic and print collections at the University of Pittsburgh. The paper is another study, based on the practicalities of the management of library materials, which provides an insight into the different processes involved in managing electronic and paper collections. At the time of writing only a draft version was available.

Five service components are defined:
collections-related component (licensing and negotiations, acquisitions etc)
backfile-related component (binding etc)
user-related components (instruction, faculty liaison etc)
use-related component (reference, bibliographic search etc)
support-related component (systems development etc)

These costs are then defined as fixed, variable or marginal, and either direct or indirect.

The cost of a collection item is defined as the annual cost added to the life cycle cost, where the life cycle cost is defined as the same as Schonfeld et al above.

Data collection for the study centred around a sixty-seven point data collection plan which is reproduced in appendix C. The results of this data mining are amongst the most comprehensive that the research discovered. A practical exercise such as this is a crucial test of a conceptual plan, such as the one that was defined in CLIR report 127.

The report is another useful examination of digital library functions.

6) Digital life cycles

This section of the LIFE research review was based around the concept of the life cycle for optimal management and preservation of digital collections. This approach is broadly advocated for the effective management of digital materials. A clear thread can be drawn through this still developing body of literature; discussion is supplied in the early work by Greenstein, Beagrie and Greenstein and Hendley through to the later applied papers, where, although less discussion is supplied, the life cycle approach is recommended.

Greenstein (1997)
In what is, perhaps, the earliest work advocating a life cycle approach, in a curatorial context, to the effective management and preservation of digital information, Greenstein discusses the problems surrounding digital collection management:

“the…issues are frustratingly inter-related. Decisions taken about whether to create or otherwise include a digital resource into a collection, for example about its content and format, will impinge directly upon how it may be managed and stored on a day-to-day basis, on how, even whether, it can be preserved, and on how it can be delivered to end users” (p 24)

In recommending how to resolve these issues Greenstein bases his framework on the life cycle of the digital resource:

“internally consistent approaches which may ensure the effective and appropriate development, preservation and use of their digital or partly digital holdings” (p 24)

The author proposes a similar life cycle to that in advocated in **Beagrie and Greenstein (1998)** (below), specifying:
Data creation
Data selection and evaluation
Data management
- Data structure (formatting, compression and encoding)
- Data documentation
- Data storage (off-line, near line, on the web or stored locally)
- Data validation (assessment, copying, media refreshment)

Resource disclosure
Data use
Data preservation
Rights management

nb: rights management is not defined as a stage in the life cycle, but rather a description of a consideration that needs to be made at every stage of the life cycle.

Greenstein then goes on to provide a sample framework policy document as established at the AHDS. In following his own guidelines Greenstein provides an insight into what he thinks a framework for management, defined around a life cycle, should look like.

This is a practical demonstration of the differences between the life cycle cost stages as outlined above in the library models, and the life cycle management stages, as advocated for digital preservation.

This report provides the first mention of data storage being a separate state from data preservation. This is a crucial concept, as the need to consider the issues surrounding the cost and management of preservation separately from storage can be revealing.

See also: **Greenstein (1997, 2)**

Beagrie, Greenstein (1998)
Beagrie and Greenstein’s report is, although much expanded, similar in its aims to **Greenstein (1997)** above: it aims to define a framework for managing digital resources which will aid the creation, management and preservation of digital resources. This framework is closely based on the life cycle of a resource.

Three main phases of the life cycle are outlined:
creation,
management/preservation
use

These high level phases are subdivided into more specific stages:
Data Creation
Data Collection Management and Preservation

Acquisition, Retention or Disposal
Data management
Data structure, format, compression and encoding
Data description and documentation
Data storage
Periodic checks of completeness
Refreshing the storage medium
Migrating the resource onto new storage media or new formats
Provision of contingency copies
Retaining a copy of the resource in its primary format
Data preservation (migration, technology preservation, emulation)
Data use
Rights management

The similarities between this framework and that advocated by Greenstein above are apparent. The report goes on to provide a set of case studies which provide example frameworks for a variety of institutions and collections, providing: data banks (Oxford University Computing Service), digitizers (a variety of institutions including the Victoria and Albert Museum, the Science Museum, the British Film Institute etc), funding agencies (National Environmental Research Council), institutional archives (the Public Record Office, amongst others), academic data archive (the AHDS amongst others) and legal deposit libraries (The British Library).

The discussion of the issues surrounding legal deposit libraries is the most directly relevant to the LIFE project.

The report concludes with a "guide to best practice", which provides a generic series of recommendations for collecting institutions. The recommendations will not be relevant to every institution, but rather are set as considerations which will be relevant where and when necessary.

Hendley (1998)
Hendley's research establishes the first life cycle based cost model for digital preservation.

He embarks with Greenstein's framework: "define and agree the context in which digital preservation is being addressed" (p 9). Digital preservation is one of the stages as defined by Greenstein etc above. The report continues to discuss the various options of digital preservation and the likely file formats to be encountered.

In chapter 4 Hendley develops a decision model for the strategy of digital preservation. This provides a seven stage plan of considerations as follows:
category of digital resource
creation
management prior to deposit
deposit
documentation
validation
data use/rights (p 46)

Each stage is related to factors such as data type, structure, storage media etc

Hendley provides a caveat to his model. He writes that his decision tree should be treated with two conditions:
firstly: unless migration as a preservation strategy is impossible, then migration should be used secondly: if migration is not impossible, then the decision tree should be used to choose which part of the strategy should be used (change media, backward compatibility, interoperability, conversion to standard format). Hendley provides a table which lists the progression of data types through his decision tree.

Hendley continues in chapter five to develop a cost model. He goes about achieving this by taking Greenstein's framework, analysing each element within the framework and assigning a cost to each element. These costs are then analysed further to isolate the costs which are directly related to preservation.

To achieve this pragmatically, Hendley took the seven elements and identified which specifically related to preservation. A schematic of this process is provided in the report:

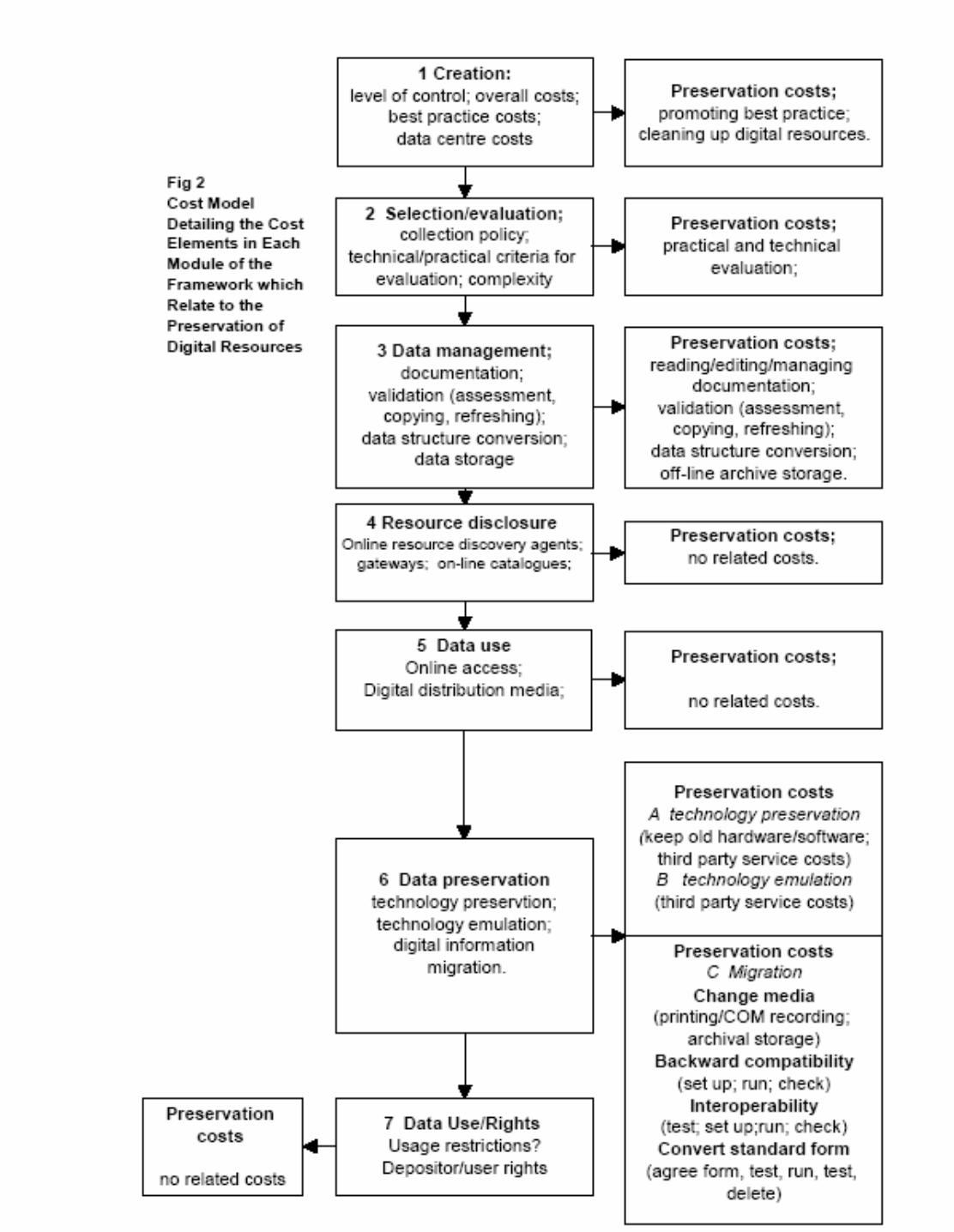


Fig 2
Cost Model Detailing the Cost Elements in Each Module of the Framework which Relate to the Preservation of Digital Resources

(p 76)
In essence, Hendley's model for costing of digital preservation is almost a top-slice of the costs for the complete life cycle. His concept is, as long as you know which costs relate specifically to preservation, then you can assign costs for it.

Hendley provides specific, costed case studies for four of his examples data sets: structured texts, official documents and visual images. He also covers the costs of commercial data storage.

Hendley provides a usable, strategic cost model for digital preservation which is based on analyses of the life cycle of the collection item. He admits that for his study to be scientific, more data and visits to institutions would be required. Nevertheless, Hendley's study is as close to a costed digital preservation life cycle as the research discovered.

Feeney (ed) (1999)
Feeney brings together the series of publications from JISC and the NPO on digital archiving.

In section 2 she lists groups of stakeholders in the digital preservation community: authors, publishers, libraries, archive centres, distributors, networked information service providers, IT suppliers, legal depositories, consortia, universities and research funders.

She goes on to re-iterate these roles by their primary interest: initiators, regulators, creators, rights holders, fund holders, providers (1), readers, archivists, providers (2) and interferers. Furthermore, these stakeholders have priorities and concerns defined as: common strategic approach by providers of preservation services, IPR, security (protection against piracy etc), financial implications (who benefits, who pays) migration and emulation from one generation to the next.

Within this context Feeney recommends the life cycle framework as advocated by Greenstein and Beagrie above, and provides a synopsis the issues as they discuss them. She also condenses Hendley's recommendations for strategy for digital preservation and his cost model.

After a discussion on rescue of digital materials, Feeney concludes in chapter 7 with "Completing the Jigsaw: Managing the Digital Preservation Process". This chapter begins with a concise but valuable summary of the "strands" within digital preservation, highlighting issues of:
Stakeholders – including rights and responsibilities
The different stages in the life cycle
Techniques of digital preservation
Evaluating digital resources to select the appropriate strategy
Identifying and estimating costs
Management of risk and rescuing digital resources

Feeney's work provides a useful, concise overview of the issues within digital preservation as defined in the JISC / National Preservation Office documents of 1997-1998.

Hodge, Carroll (1999)
Hodge and Carroll's interesting discussion provides an overview of digital archiving issues at the time of writing (1999).

The exercise collected data from 19 projects which it selected as exemplars of best practice. It provides a discussion on "organisational models" (institutions which digitally archive material) isolating: data centres, institutional archives, third party repositories, publishers and "legal depositories" (national libraries and archives). A discussion of the, then draft, OAIS reference model completes the section.

The report introduces the concept of life cycles by giving a perspective on the “players” within a life cycle model. The advocated model is loosely based on Greenstein and Beagrie’s framework. Hodge defines the following stages:

Creation
Acquisition and collection development
- Collection policies
  - Selecting what to archive
  - Determining extent
  - Archiving links
  - Refreshing the archived contents
- Gathering approaches
- Intellectual property concerns

Cataloguing and identification
- Metadata
- Persistent identification

Storage
- Hardware and software migration
- Refreshing the media
- Backup and recovery

Preservation
- Refreshing the site contents
- Retention
- Standards, Transformations vs. Native Formats
- Preserving the look and feel

Access
- Access mechanisms
- Rights management and security requirements

Although, symptomatically of the time it was written, the report does concentrate on issues which are specific to web archiving (archiving of links, refreshing archived contents and so on), its central discussions are relevant to LIFE because the report establishes a link between library environments and data environments.

The report’s discussion of costs is still relevant today:
“Although cost is recognized as a basic driver in DEA [digital electronic archiving], it was also the most difficult aspect on which to gather information”
“Until several large archives have gone through at least one or two migrations or emulation developments, it will not be possible to separate the cost for the archives from the cost of doing business.”

The conclusion provides a list of recommendations.

The discussion of the life cycle in the report is a useful, slightly altered perspective, to the JISC UK studies outlined above.

Hodge (2001)
Further to her 1999 paper, Hodge wrote this report published by the Sheridan Press in 2001; the research comes from the perspective of a publisher and is a general discussion of digital preservation issues.

It is notable because it provides a recommendation for the life cycle approach to collection management whilst coming from a publishers “information life cycle” perspective.

The report provides a discussion of the roles and responsibilities between the stakeholders in digital preservation and advocates the high level archival functions as laid out in the OAIS reference model.

The report concludes by providing some recommendations for actions by publishers.

Jones, Beagrie (2001)
Jones and Beagrie's handbook is widely recognized as the definitive reference work on digital preservation. Its scope is wide, providing chapters on institutional strategies, organisational activities and media and formats, as well as an overview of digital preservation. The handbook is extensively covered in the literature available, so, for the purposes of this report, I will only provide discussion of the areas relevant to LIFE. Namely: life cycle management, costing issues, and roles and responsibilities within digital preservation.

In discussing cost issues, the handbook, mirroring **Ashley (2000)** (below), advises caution: "there is a wide and potentially misleading amount of project-related data on costs which may or may not have any bearing on the costs of managing digital materials long-term" (p 27). There is also advice for collaboration (p 28) and a warning that the amount of data and the level of access provided will make a difference.

The discussion of roles and responsibilities in the handbook provides signposts towards the resolutions required: extra-institutional roles, intra-institutional roles and the responsibilities that data creators should take.

The life cycle framework, as defined by Beagrie and Greenstein above, is broadly recommended in the handbook. In defining life cycle management, the handbook traces the concept from records management through to its application by Greenstein and Beagrie (above):
"The major implications for life cycle management of digital resources, whatever their form or function, is the need actively to manage the resource at each stage of its life-cycle and to recognise the inter-dependencies between each stage and commence preservation activities as early as practicable. This represents a major difference with most traditional preservation, where management is largely passive until detailed conservation work is required, typically, many years after creation and rarely, if ever, involving the creator" (p 11)
This excerpt defines the difference between the life cycle costing cycles, as discussed above with relation to Stephens etc, and the life cycle management cycles as discussed in this section.

Despite the difference in the approaches and their lineage, a combination of the two concepts would be useful for digital library materials. This, in essence, is the aim of LIFE.

Chapter 4 is designed to: "provide pointers…and guidance aimed at encouraging good practice in creating and managing digital materials", and isolates the following stages in the management of collection items:

Creating digital materials
- Creating digital surrogates
- Creating electronic records

Acquisition and appraisal, retention and review
- Appraisal and selection
- Retention and review
- Accessioning
  - Transfer procedures and guidelines
  - Procedures to prepare data and documentation for storage and preservation
    - Unique numbering
    - Preferred marking and labelling
    - Handling guidelines
    - Validation

- Scanning for computer viruses
- Checking media and files can be read
- Checking completeness and accuracy of documentation
- Checking description and intellectual content of the resource
- Checking structure and formatting of resource
- Procedures for documenting validation checks
- Procedures for checking and resolving discrepancies with the supplier

- Re-formatting file formats
- Re-formatting storage media
- Copying
- Security

Cataloguing and documentation Procedures

- Cataloguing
- Retrospective documentation or catalogue enhancement
- Edition and version control
- Cataloguing and documentation standards
- Processing times

Storage and preservation

- Storage and maintenance
  - Storage media and file formats
  - Management of media and systems
    - Media refreshing and reformatting
    - Disaster recovery planning
    - Environmental conditions
    - Care and handling
    - Audit
    - Security
    - Management of computer storage
- Preservation strategies
  - Primary preservation strategies
    - Migration
    - Emulation
  - Secondary preservation strategies
    - Technology preservation
    - Adherence to standards
    - Backwards compatibility
    - Encapsulation
    - Permanent identifiers
    - Converting to stable analogue format
    - Digital archaeology

Metadata and documentation

- Metadata
- Documentation
  - Technology
  - Change
  - Rights management
  - Continuity
  - Accountability
  - Authenticity
  - Cost
  - Feasibility
  - Future

Access

- Storage and security
- Legal

Media
Technical

The terms enumerated above are sections and sub-sections in a chapter designed as management considerations, and are not defined stages in a life cycle. However, on examination one can see that many are approaching life cycle phases. If the above were to be used as a model it would be very detailed; it does, nevertheless, provide a comprehensive list of considerations in the life of a digital collection item.

The Handbook provides an excellent overview of digital preservation activities. It, once again, provides a broad recommendation for the life cycle management of digital materials, and the similarities are apparent between the stages listed above and the life cycle stages laid out elsewhere in this report.

Muir (2001)
Muir's 2001 report summarises the research and publication activity in a number of arenas directly relevant to LIFE. The issues are highlighted as part of the context of the legal deposit of digital materials.

Muir's synopsis of the issues covers the following broad areas:
identification
selection
acquisition
accession and processing
preservation
access

She also continues to discuss the concept of life cycles, referring to it as a "tool for looking at the challenges of digital preservation" (p 667); once again it is the stages defined in Greenstein and Hendley that are cited:
resource creation
resource selection and evaluation
resource management
resource disclosure
resource use
resource preservation
rights management.

There is also a discussion of costs for digital preservation. Muir isolates studies put out by the British Library, Yale University, but, again, concentrates on the study by Tony Hendley. These stages, actually mirroring the section of the report they are discussing, are defined as:

define the key tasks involved in digital preservation;
review the three preservation strategies – migration, emulation, technology preservation – given in the study remit;
define all the digital information resources and data types covered by the study;
develop a decision model to assess categories of digital resource and select the most appropriate preservation strategy; and
develop a cost model to assess costs according to category and preservation strategy and also to allocate costs to the stages in the management process

Muir's article is a useful distillation of the work done on these areas prior to 2001.

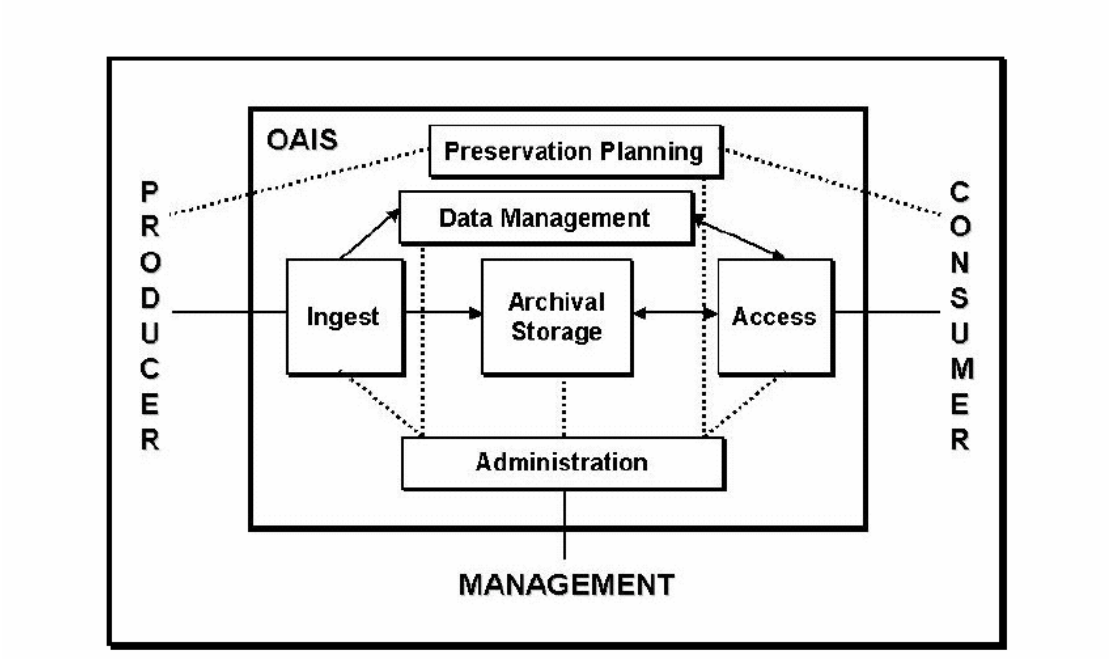
Reference Model for an Open Archival Information System (OAIS) 2001

It is generally accepted that the OAIS reference model should underpin all digital preservation activities. It broadly advocates a life cycle approach to archiving of electronic information.

The reference model defines a high level set of mandatory responsibilities. An OAIS archive must:
Negotiate for and accept appropriate information from information producers
Obtain sufficient control of the information in order to meet long-term preservation objectives
Determine the scope of the archive's user community
Ensure that the preserved information is independently understandable to the user community, in the sense that the information can be understood by users without the assistance of the information producer
Follow documented policies and procedures to ensure the information is preserved against all reasonable contingencies, and to enable dissemination of authenticated copies of the preserved information in its original form, or in a form traceable to the original
Make the preserved information available to the user community

The reference model also defines a high level functional model, which I will not concentrate on extensively here, as the terms are well known:

Ingest
Archival storage
Data management
Administration
Preservation planning
Access



As a functional model of a work flow, these terms can be understood as an archival life cycle.

Baudoin, Smith (2002)
The report describes the Massachusetts Institute of Technology (MIT) Mellon funded project to provide an archive of "dynamic" electronic journals, where dynamic is defined as having: "moving elements" or "scripts". The report provides a discussion of preservation techniques and the necessity to preserve electronic journals.

There is a discussion of different types of dynamic e-journals (for example: dynamic content mapping, dynamic editorial process, journals with dynamic elements) and a consideration of metadata - concluding that METS is a useful standard to use. The report uses DSpace as the "physical" infrastructure for housing the archive.

The report concludes that further research is needed on preserving dynamic e-journals; however, it provides a useful perspective on the necessity to provide practical experience in areas surrounding e-journal archiving.

Ockerbloom (2002)
The description of the Mellon funded e-journal archiving project at the University of Pennsylvania is useful as it is firmly based in traditional library functions. As such it provides a useful perspective for the LIFE project.

The report discusses the requirements of a trusted repository as established in the literature, focussing on the RLG/OCLC paper and OAIS.

The report provides a breakdown of the organizational models that it perceives within digital preservation:
Self archiving [akin to an institutional repository]
Integrated responsibility [akin to a traditional library's print function]
Distributed responsibility [akin to LOCKSS]
Service providers [akin to a 3rd party preservation service such as ULCC]
Registries

Closely related is the discussion of "archival rights and responsibilities" which breaks down individual stages within the life cycle of an archive and seeks to assign responsibility for these stages:
Responsibilities for selection
    who chooses
Responsibilities for ingestion
    who assigns what metadata
Rights and responsibilities for storage and maintenance
    including who is responsible for migration/emulation of content and so on
Rights and responsibilities for access and distribution
    who decides what should be available to who and how

Although these specifics are put in the terms of roles, the stages themselves are issues which are central to digital collection management; and, indeed, if the perspective is changed then the stages are on the life cycle of the management of the resources.

Following on from this discussion, the report establishes what it calls the "archival life cycle", reproducing the stages in the OAIS model as outlined above:
Ingest
Archival storage
Data management
Administration
Preservation planning
Access

Although, by its own admission, the project did not achieve all it set out do to, the report provides a very useful strategic, library based, exploration of the issues and problems surrounding local storage of e-journal content in an academic environment.

Harvard University Library (2002)

This paper describes the Harvard report to the Mellon foundation on its e-journal archiving activities.

The report aims to provide an overview of all functions of the archiving process:
“to explore and define both the business and technical issues of content, format and deposit mechanisms, access control and interface requirements, long-term preservation guidelines, costs of development, operation and maintenance of the working archive, and financial and governance models for a sustainable archive” (p 3).

There is discussion of a business model, access issues (who, what, how) with consideration of authorized users and trigger events, and economic issues – concluding that operational costs of archiving will be centred in only a few places

The technical model for the archive is established: it was based on the Digital Repository Service of Harvard’s Library Digital Initiative, a system conceived in “relation” to the OAIS reference model. Unsurprisingly, the functions of the archive (the nearest thing to a life cycle) follow the OAIS reference model, enumerated as:

- Ingest
  - SIP
    - Submission session
    - Quality assurance
    - Descriptive information
    - Transformation of SIP to AIP
  - Data management
    - Bibliographic control
    - Naming (i.e. persistent identifiers)
  - Archival storage strategy (i.e. RAID discs etc)
  - Preservation strategy
    - Preservation strategy
    - Levels of preservation service
    - Policy implications
  - Access
  - Administration
- Schedule (i.e. what to test and review and when)

The SIP is provided by METS and the unit of submission is the e-journal issue, with the unit of submission being three layered (title, issue, item). The following discussion provides a useful, practical discussion of e-journals in relation to the submission information package.

Generally, the detailed discussion of the OAIS functions in a practical, library context in relation to e-journals does provide a useful ‘life cycle’ of the archived items. The level of detail provides an interesting alternative to the sorts of life cycles proposed above by Greenstein and so on.

The report concludes by isolating the following roles and responsibilities:

- Internal roles and responsibilities:
  - Technical development
  - Archive content development
  - Curatorial responsibilities
- External
  - Stakeholders
  - The archival community
  - Sharable infrastructure

Overall the report provides an excellent exploration of practical e-journal archiving with a useful context for the life cycle model.

Yale University Library and Elsevier Science (2002)
The Yale report to the Mellon Foundation discusses both the need for digital preservation itself and the need for research into preservation strategies; it also establishes that the model archive will be defined within the OAIS model.

The report provides a useful discussion of "trigger events" which demarcate when a publisher would turn their content over to an archival agent:
loss of access or abdication of responsibility (for example: publisher goes bust)
lapse of a specific period of time (for example: JSTOR)
on site visitors
archival uses
metdata uses
The trigger events mentioned above are effectively discussions of the roles surrounding digital preservation.

Demonstrating the different perceptions of an archival life cycle which exist, the report proposes the following cost stages:
The difficult part (development and start-up)
The easier part (ongoing maintenance and problem resolution)
The tricky part (collaboration and standards)
The messy part (comprehensiveness)
The part where it becomes difficult – and probably very expensive – again (migration)

The report goes on to discuss models for the funding of an archive:
Up-front payment
Ongoing archival fees
The traditional library method
Fee for services operation
Hybrid (that is: an amalgam of the above)

The Yale report also isolates issues which would occur within the use of an archive of e-journals:
Selection and appraisal
Preservation of structural information
Guaranteeing authenticity

Metadata is discussed with reference to OAIS and other projects (InterPARES, CEDARS). Yale worked with Elsevier on the project and there is an exploration of the production process of the publisher (and the resulting format such as Elsevier's EFFECT standard) with relation to digital library systems (METS, OAIS, OAI) and so on. The fact it is possible to translate proprietary xml standards into a required xml format is widely used in the archiving of e-journals.

The report provides another useful, practical exploration into an archiving exercise and the associated challenges.

Sanett (2002)
Shelby Sanett aims to develop a cost model "specific to preserving authentic electronic records" by "applying business concepts, in combination with archival precepts and collection management principles" (p 388).

She outlines a research review, invoking Hendley, and Russell and Weinberger and their respective cost models for digital preservation. In her discussion of Hendley, Sanett makes an observation which sums up the philosophy of LIFE:
"Generally, the breakdown of cost factors corresponds to the life cycle stages of the data" (p 390)

The report describes the work and background to the InterPARES project (to investigate appraisal, authenticity, preservation and strategies) for preserving electronic records. The project mapped the preservation activity using Integrated Definition for Function Modelling (IDEF) and then surveyed thirteen preservation projects. “Cost categories for preserving authentic electronic records were mapped upon the preservation process model” (p 394), this model was monikered IDEF-0
Three cost categories were identified for preservation activities: costs for preserving electronic records, costs for use and user populations. These costs are as follows:

Costs for preserving electronic records
Part 1, capital costs
- Software development
- Hardware (for preservation processing)
- Research and development
- Facilities
- Interface design for processing electronic records

Part 2, direct operating costs
- Identify potential records
- Evaluate/Examine (negotiate IPR)
- Acquire records (staff and purchase or royalty payment)
- Establish Inventory Record
- Process (prepare for preservation, confirm authenticity/integrity of record)
- Produce metadata
- Preserve (select and implement appropriate strategy)
- Storage (container/other)
- Maintenance (refresh/migrate)
- Monitor
- Evaluate

Part 3, indirect operating costs (overhead)
- Indirect staff (supervision, clerical support, benefit times, training times, unallocated times)
- Facilities (rent, utilities, off-site storage of records))
- Amortization of capital costs
- General and administrative (hr, accounting, funding development and grant writing, staff training and professional development, partnerships with other institutions policy development)

Costs for use of preserved electronic records
Part 1, capital costs for use
- Equipment, software, user training, facilities, interface design etc

Part 2, direct operating costs for use
- Storage, royalties, communications, records access mechanisms.
- Staff for monitoring, user query response and services, records access management

Part 3, indirect operating costs for use
- Indirect staff, facilities, amortization of capital costs

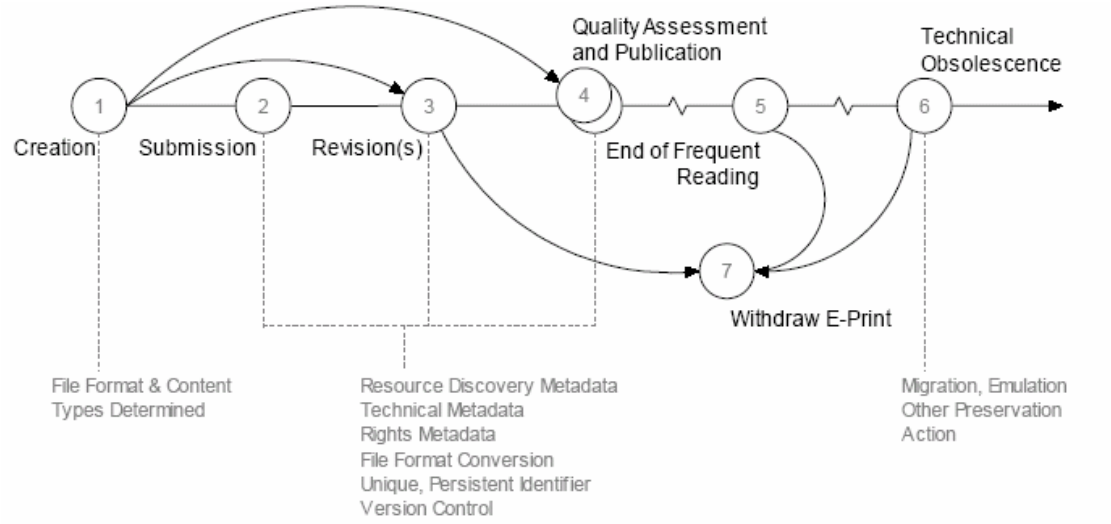
Notes on the above:
i) Capital costs for preserving records are costs incurred at the beginning. They must be amortized over a time period such as 5 years, which can then be used as the period for present value calculations
ii) Indirect and direct operating costs for Preserving Electronic Records are costs incurred on a yearly basis. They should be brought to Present Value (the value now of money expected to be received in the future). The period of 5 years is suggested because the magnitude of the

investment in hardware and software is great enough to justify replacing at five years rather than earlier.
iii) The sum of i) and ii) together are the total costs for Preserving Electronic Records brought to present value. The cost per item preserved is i+ii/(total number of items preserved).
iv) Operating costs for the use of Preserved Electronic Records are incurred on a yearly basis. These costs should be brought to present value.
v) The sum of iii) and iv) is the total present value for preservation and use of electronic records. The cost per use is iii+iv/(Total use of electronic records over five years (or the period used for present value calculations).).

Although, as observed before, it is not defined as such, if Sanett's research provides a life cycle model, then the costs for preserving electronic records, as reproduced above, is it. The cost model provides an interesting alternative to those that mirror the OAIS model and that espoused by Greenstein and so on above.

James, Ruusalepp, Anderson, Pinfield (2003)
In their JISC commissioned paper on the preservation of e-prints James et al provide an insight that is relevant to LIFE. As would be expected, the paper provides the background to the e-print movement, with reviews of properties, file types and metadata formats common in e-prints.

In chapter 6, the discussion of the properties of e-prints, a schematic of the typical life cycle of an e-print is reproduced:



(p 18)

Here the familiar life cycle management stages (for example: application of metadata) are imposed onto something akin to a publishing life cycle. This perspective provides another interesting comment on the cross application of the concept of life cycles in the information environment.

Chapter 9 is explicitly on cost models. There is consideration of the cost elements isolated by the CEDARS project and the report continues that physical storage costs can be planned for on the basis of the amount of material being deposited and the average size of submission, combined with the estimated cost of storage equipment. However, these costs are deemed as likely to be insignificant to the costs associated with:
negotiating rights
managing proprietary file formats
cost of creating additional metadata (especially technical and administrative)

The investigation produces its own model of the CEDARS "taxonomy of archives" (see below) and also defines "e-print life cycle cost elements", which are the costs as related to the events in the schematic above; these are:
submission and revision (costs surrounding comparison with collection policy)
publication (retention or removal at publication elsewhere)
retention assessment (retention or removal on some form of value assessment over time)
technical obsolescence (decisions as to whether to emulate, migrate etc)

This report is centred, obviously and necessarily, on e-prints; however, it provides a valuable perspective on issues central to digital preservation of specific collections as well as on life cycle management.

Hodge (2004)
In this updated version of her 1999 report, also produced for CENDI and ICSTI, Hodge expands on the previous work with the context of the last 6 years. She provides an overview of selected systems and isolates the trends that have emerged.

The report highlights 21 systems and addresses "scientific information".

Section 4 is a discussion of roles and responsibilities, covering: publishers, national libraries, institutions (research libraries), museums, national archives, trusted third parties, and government and other funding sources. There is a discussion of the types of media that form the corpus of scientific information and a discussion of file formats.

Section 8 provides an exploration of common workflows found across the highlighted archives. Stages are defined as:
selection
ingestion
metadata creation
archiving and transformation
storage
dissemination

Within these stages there are some secondary steps discussed. Varying approaches to selection are highlighted, including methods such as: submission and harvesting. Metadata creation is also considered, with the paper proposing that three methods of metadata creation exist: metadata generators, metadata templates and metadata editors, which respectively require varying level of time and human commitment. Within archiving, transforming to a standard preservation format, migration, and migration on-request, are discussed.

As this report found before, these stages are akin to life cycle steps, even if they are not defined as such in the paper.

Under section 11, "New issues and the research agenda", there is a discussion of "Costs and sustainability". The section is valuable and pertinent to LIFE in providing a literature review of published cost models.

In summary, the report provides a good general overview of practical activities in the intervening time between the two papers and demonstrates the speed which developments in the broad arena of digital preservation occur.

Phillips (2005)
In this effective exploration of the costs of the management of the National Library of Australia's (NLA) "Australia's Web Archive" programme, Phillips adopts a life cycle methodology to the allocation of costs across the acquisition of "instances" (an instance refers to each version of a site that is collected) of the harvested websites.

The report considers: staff costs, administrative costs and infrastructure development costs. Indirect costs (the provision of work stations and so on), building maintenance and, notably, the costs of preserving the archive were excluded. Then cost drivers (once again, these fit within what are defined as life cycle stages in the LIFE project), were established, these were defined as:
identification and selection;
publisher contact (including permissions);
gathering, quality assurance and archiving;
cataloguing; other activities;
partner liaison and support.

The relevant data was then extracted.

Costs were established as: staff cost per instance: AUD$168.36, supplier costs: AUD$3.41 and infrastructure development: AUD$6.91. Within these costs the “drivers” (or life cycle stages) were costed at the following levels: identification and selection:
publisher contact (i.e. permissions): AUD$10.16
gathering, quality assurance and archiving: AUD$10.34
cataloguing; other activities: AUD$27.42 (or AUD$59.67)

Interestingly, before concluding, the paper discusses ways in which cost reductions may potentially be achieved. These potentially include the supply of metadata with harvested websites and the automation of quality assurance.

Although the paper does not provide preservation costs it provides an excellent demonstration of how the concept of life cycles can be used to cost digital library processes.

7) Records management
Records managers have long employed life cycles to ensure the efficient stewardship of records. This strand of life cycle management is developed in work such as Jones and Beagrie (2001) above.

It is unnecessary for this report to explore the arena of life cycles within records management to any great extent. The following section provides a very brief sweep.

A useful guide is provided by the Public Record Office, in: **Public Record Office (1999)**
The handbook provides a succinct summary:

“Records, whether electronic or paper, pass through identifiable phases in their lifecycle from initial creation to final disposal. At each phase of the cycle, electronic records need to be actively managed according to established procedures, to ensure that they retain qualities of integrity, authenticity and reliability.” (p 43)

The classic stages in the records management life cycle are:
capture (creation and addition into an information management system)
disposition (a decision on the retention period for the record)
appraisal (process of making decisions on initial disposition and final disposal)
preservation (migration through technologies etc)
disposal (discard or transferral to a permanent archive)

These stages are useful and are generally applicable as a consideration in a digital library background. This theme is further developed by Gilliland-Swetland (2000).

Gilliland-Swetland (2000)

Gilliland-Swetland advocates the use of records management principles for the organization and preservation of digital information; this includes the adoption of the records management life cycle.

The concept and endorsement of using records management principles for digital cultural heritage material is a valuable perspective:
"The archival community is making significant contributions to research and development in the digital information environment by using integrity, metadata, knowledge management, risk management, and knowledge preservation. Each area is discussed below with reference to recent and ongoing projects in which the archival community has played a leading role in setting the agenda or integrating the archival perspective. Many of the projects discussed have in common a concern for evidence in information creation, storage, retrieval, and preservation; cross-community collaboration; strategies that use both technological processes and management procedures; development of best practices and standards; and evaluation" (p 21)

Projects discussed include CEDARS and InterPARES.

Upward (2000)
Upward provides an excellent introduction to the concept of the records continuum which is gaining popularity as a term rather than the linear, records life cycle. Jones and Beagrie (2001) also make reference to this factor.

See also: **McKemmish (2001)**.

8) Digital Preservation (costs)

Ashley (2000)
In his paper given at the DLM-Forum on electronic records in 1999, Kevin Ashley disabuses the misapprehensions that he perceives surrounding the costs of digital preservation. In particular:
"False belief 1: Archive costs depend primarily on the volume of data
False belief 2: Data storage costs are frighteningly high"
(p 123)

Rather, he believes that the costs to think on when considering digital preservation are analogous to those "which influence a traditional library or archive" (p 123).

He demonstrates that prices per bit are dependent on the specific circumstances of a particular digital archive and are therefore not reliable for generally applicable cost models.

He does propose some variables which will affect price:
How many items?
How big are they?
How do they vary?
Who can access them?
How often, how quickly, will access occur?
What control do you have?
What descriptions are required?
Do resources arrive in neat bundles?
Is metadata attached?
Is selection by policy or individual appraisal?
Is access random or to bundles of objects?
Must non-digital sources also be acquired?
Is material current or obsolete?
Was archiving considered in the application?
What is the service model?

Overall Ashley provides his unique and practical perspective on the costs of digital archiving.

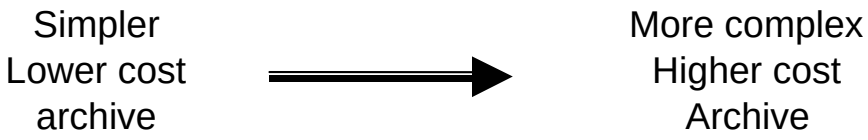
CEDARS (Curl Exemplars in Digital Archiving)
"Not a great deal is known about the costs of preserving complex digital objects over time. However, there is a perceived wisdom within the library community that it will be more expensive and more intensive than preservation of traditional library materials. This may not prove to be the case, as the costs involved in traditional libraries are also fairly unknown quantities", The CEDARS project report (p 67).

"Digital materials have a different lifecycle. Ongoing activity is needed to ensure continuing access. The way a digital object is created influences how (or indeed whether) it can be preserved. Likewise, decisions taken at the start-point of preservation can impact on future access."
The CEDARS project report (p 68).

All the papers put out by the project should be considered as relevant to the aims of LIFE; a list of papers is available on the CEDARS site: http://www.leeds.ac.uk/cedars/pubconf/pubconf.html. This report will specifically discuss those with the most direct relevance: Towards Collection Management Guidance, Cost Elements of Digital Preservation, the CEDARS Guide to Digital Collection Management.

Russell, Weinberger, Granger (2000)
This report describes the results of the findings of the CEDARS project regarding the costs of digital preservation. There is a general discussion of the issues surrounding costs, including a discussion of the life cycle of a resource and cost benefit analysis.

The report proposes a conceptual taxonomy of archives:



Data types & formats	Limited number.	Large number.
Rights	Ownership	Non-ownership
Control	High degree of control	Low degree of control

(p 5)

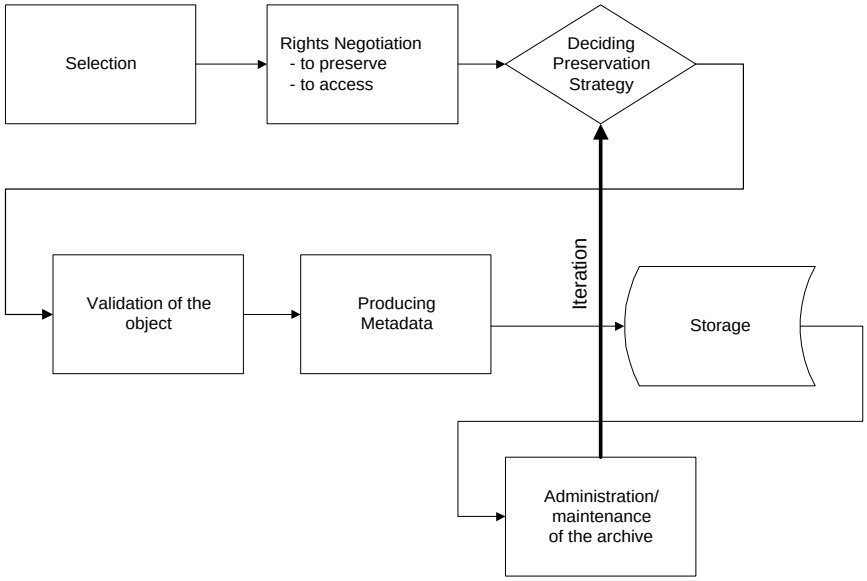
which, although is not a cost model, is an excellent tool when considering the expenses surrounding managing an archive.

The cost elements isolated are:

Selecting a particular digital object for preservation

(taken by collection managers and systems managers)
Negotiating the right to preserve the object
Negotiating the right to provide access to the preserved object
Determining the appropriate technical strategy for preservation and continuing access
Validating the completeness of the object on delivery to the archive
Producing metadata
Storing files
Administering the archive

This is also represented as a chart:



(p 11)

This is closely related to the life cycle of the collection item. The iterative arrow is also a very useful concept for consideration of an object in the archive.

The report concludes by stating that the more infrequently that the arrow is traversed the less the digital preservation is likely to cost. Therefore if one takes action to ensure the arrow is traversed less often, then one will reduce the cost of the archive. This is akin to taking steps early in the life cycle to ensure preservation is as easy as possible at a later time.

CEDARS Guide to digital collection management (2002)
The CEDARS guide to digital collection management also provides a discussion of the life cycle of a resource. Effective life cycle management across digital collections is recommended to ensure longevity.

The report proposes a cost model which mirrors the stages in the life cycle. The costs fall into three categories: one off or up front costs; long term or ongoing costs, and costs that vary. There are parallels between these costs and those defined by Schonfeld et al above.

The full breakdown of costs runs as follows:

Upfront costs
Establishment or enhancement of digital archive infrastructure
This will also be ongoing to keep systems up to date
Selection of materials for archiving

- IPR issues
  - This will also be ongoing
- Consideration of continues access to the object over time
- Validation of integrity
- Preservation metadata

Long term or on-going costs:

- File storage
- Archive administration
- Evaluation and revision

Costs that are likely to vary over time:

- Technical Strategies for continuing access
- Metadata production costs
- Rights negotiation costs [according to whether:]
  - National libraries reach agreements with publishers
  - Standard licenses are available which allow digital preservation
  - An exception to the EU copyright is passed
  - LDEP is introduced

Also relevant is the report's analysis of the necessary collection management policies. These are recommended for the following stages:

Selection of materials

- Archived
- Served
- Mirrored
- Linked

Acquisition and organisation of materials within the collection

- Receipt
- Verification of the object's integrity
- Decisions regarding the long-term role of the material within the collection, including the assessment of the object's significant properties
- Cataloguing (including the assignment of unique identifiers and other preservation metadata)
- Classification within the collection
- Provision of discovery aids (for example, through an OPAC)
- Provision of Access to the material
- Application of appropriate access controls and security
- Consideration of actions necessary for ensuring the object's long term preservation (for example, conversion of materials to designated archiving formats as detailed in a collection management policy)

Storage and access to materials

- Preservation and continuing access
- Storage of archived materials
  - How materials are moved from acquisition to permanent storage
  - How the storage hierarchy is managed and by whom
  - How the storage media are refreshed and how often
  - How objects are to be disseminated from the repository
  - Disaster recovery, including:
    - Rolling program of media refreshment
    - Geographically distributed management systems
- Access to materials

Digital preservation strategies and library policies

De-selection and reformatting

This paper provides a large amount of information on the phases that items go through in a typical collection. From the perspective of the LIFE project there is much that is suitable for consideration.

A full list of CEDARS publications can be found in the bibliography of this paper.

CAMiLEON
The CAMiLEON project provides a number of different papers discussing practical exercises in digital preservation strategies. These papers are useful illustrations of what can be achieved with practical, technical exercises in format migration and emulation. They also provide an interesting mention of the classic 1980's computer game Chuckie Egg. See **Wheatley (2001)**, **Granger (2001)** and **Mellor, Wheatley, Sergeant (2002)** below.

The papers discussing practical issues of migration on request (2002), migration (2001) and emulation (2001),, where interestingly Granger notes:
""it [emulation] could prove to be much more cost effective solution in certain circumstances for the reason that producing one emulator could be much cheaper that migrating every digital object in an archive"
are especially useful examples.

Crespo, Garcia-Molina (2001)
Crespo and Garcia-Molina's report provides insight into the estimation of costs of an archival repository with specific reference to its technical architecture.

It introduces ArchSim, a simulation tool for archival repositories.

The report concludes that the total cost of an archival repository is composed of a series of cost events; if a financial value can be assigned to each cost event then the total cost can be obtained.

A set of cost "sources" is proposed which go toward building the cost events. These sources are categorised as follows:
Hardware and software
Non-labour operational costs
Labour costs
Information acquisition
Insurance
Unavailability
Cost of losing a document

These sources build the following events:
AR Creation
Document access
AR operation
Failure detection
Repairs
Preventive maintenance
Upgrades

Wright (2002)
Richard Wright describes the efforts of PRESTO, a project to develop broadcast archive technology.

The report discusses the various options available to the project and recommends a life cycle approach to the preservation of broadcast materials:

“Cost per use:
True cost of an asset is total lifecycle cost. True benefit is related to the number of times that asset is used over the lifecycle. Archive preservation strategy should aim at the “lowest cost per use” (p 4).

These issues are also discussed in **Wright (2004)**.

Electronic Publishing Services (2002)
This report applies a model analogous to a life cycle costing methodology to the voluntarily deposited material at the British Library and other legal deposit libraries (LDL’s). The report was compiled to explore the likely increases in expenditure that the LDL’s and other stakeholders would face with the introduction of electronic legal deposit.

The costs for 2001/2 were calculated and then extrapolated across 2003 to 2005 to try to work out the impact of the legislation in the approaching future.

The figures were based on staff time spent on the processes (life cycle stages) which incur costs; these costs were then extended according to predictions about how much material was predicted to be deposited.

The following stages were isolated:
Selection
Accessions
Cataloguing
Storage and preservation
Metadata
Access
Other technology costs
Management

More information is given by the report about the intricacies within the above stages; the assumptions and observations that the report makes are sensible.

As has been found in so many ‘life cycle’ costing models of this type, accurate costings for preservation of the material were not available at the time of writing. Capital costing of the (then) planned DOM (Digital Object Management system) is mentioned, but these costs:
“do not cover the input of metadata needed for technical, administrative and preservation purposes…Accordingly, costs for the input of technical metadata have been included in the cost model at the end of this chapter on the basis of thoroughly discussed and agreed throughput rates” (p 22).

These costings and this ‘life cycle’ model are a valuable addition to the body of work as they provide practical figures in a digital library, and more specifically, in a legal deposit environment.

Erpanet, Cost orientation tool (2003)
This tool, one of a series to appear on Erpanet, introduces the issues surrounding costs in a digital preservation context. It establishes a matrix of factors which will have an impact on cost:

Objects:
- Influence on creation
- Existing
- Complexity
- Preservation period
- Appraisal/value

People
- Skills

- Quality
- Training
- Experience

Standards
- Standards

Practices
- Workflow
- Operation
- Processes

Systems, methods and technologies
- Preservation method
- Validation method
- Sustainability
- Portability
- Components
- Maintenance
- Operation
- Flexibility
- Facilities
- Class of preservation
- Modularity

Law and policies
- Legislation
- Policy

Organisation
- Relationship building
- Capacity building
- Responsibilities

Granger (2002)
A series of useful presentations on cost models for digital preservation and related activities.

Chapman (2003)
Stephen Chapman examines the real costs of digital preservation in comparing the costs for the Harvard Depository (from the Harvard University Library) and the OCLC Digital Archive.

Chapman notes that the OCLC archive charges at three rates per gigabyte on a sliding scale dependent on the amount of storage taken up, and that the costs are for bit preservation only, not, at the time of writing, for "full preservation" where the intellectual content can be rendered accurately regardless of "technology changes" over time.

Chapman makes mention of full life cycle costs:
"Acquisition specialists and other managers may calculate ongoing preservation costs for digitized and born-digital materials. By adding these to initial costs for purchase, processing (for example, cataloguing) and deposit, one may then estimate full life cycle costs for stated retention periods" (p 4).

The report provides a comparison of the storage costs for hard copy formats and various file formats (ASCII, TIFF etc)

The report comes to a telling conclusion, which reflects **Ashley (2000)** above:
"Thus, managed storage costs are not fixed, but arrived at collection-by-collection by judicious decision-making. The choice of repository, the scope of service, the repository pricing model, and owner's decisions regarding formats, number of items, number of versions, and number of collections to deposit: all are potential variables, and therefore instruments, to negotiate for affordable prices for managed storage services from centralized repositories." (p 13)

This is an illuminating exploration into real costs of preservation systems and is accurate in stating that there is no “magic bullet” formula for costing digital preservation, but, rather, that the costs will vary from case to case, depending on numerous, specific circumstances.

Barton, Walker (2003)
This paper provides a “snapshot of our [DSpace’s] business strategy in fall 2002” (p 2). DSpace is open source digital repository software, which, at the time of writing (2003), was MIT’s institutional repository.

The experiment developed a cost model to:
“capture the full economic cost of operating DSpace including staff impact, space hardware and other Library resources” (p 3).

To affect this, the report gathered data from various places, including: staffing records, MIT central accounting and MIT Libraries records.

To develop a cost model the costs were classified as incremental (costs that will create new expense categories), principal or comprehensive. These costs were then allocated to staff salaries, operating expenses or system equipment escrow.

This paper provides another useful, practical exercise in applying costing models to practical situations and analysing the result.

Oltmans, Kol (2005)
Oltmans and Kol of the Koninklijke Bibliotheek discuss life cycle management of digital collections, with specific reference to the digital preservation strategies, emulation and migration.

The paper proposes an update to Shenton’s (above) life cycle collection management formula, providing cost stages for ingest and storage:

$K(t,a)=s(a)+i(a)+h(t,a)$
Where $K(t,a)$ is the total cost of handling a objects for a period of t years, where s=selection, i=ingest and h=storage

The paper suggests further additions to the above formula for specific digital preservation strategies:

Migration
$K(t,a)=h(t,a)+m(t,a)$
Where $K(t,a)$ is the total cost of holding a objects for a period of t years, where h=storage costs and m=migration costs

“A new variable is introduced that expresses the costs of migrating an object. The costs of migrating digital objects is dependent on the time t (the longer we preserve the objects, the more often we have to convert them) and on the number of objects a (the more objects in the archive, the more conversions have to be executed)” (p 6).

Emulation:
$K(t,a)=h(t,a)+E+e(t)$
“Where $K(t,a)$ is the total cost of handling a objects for a period of t years, where h=storage costs, E=costs of setting up the emulation virtual machine, and e(t)=costs of emulation over time.” (p 6)

Oltmans also provides a spreadsheet tool, based on the formula above, which is designed to predict future costs for digital preservation activities. The sheet has variables of cost for migration of file, cost of set up of emulation virtual machine and number of files.

The paper provides a specifically digital update to Shenton's formula. It also provides an interesting perspective on the potential costs of preserving large numbers of file formats. The LIFE research found this sort of exploration infrequently, and it is a valuable addition to the literature on life cycling and digital preservation strategies provided from the perspective of a practical digital preservation archive.

Linden, Martin, Masters, Parker (2005)
This DPC Technology Watch Report describes the British Library's selection of the technology which will underpin its planned, large scale storage and preservation system.

The paper briefly introduces the issues surrounding the background to procuring large scale storage systems, including: total cost of ownership (TCO), the technical storage background, the IT storage market and so on.

The specifics of the selection process and requirements are discussed, with 300TB of storage required over the next 5 years

The storage was put out to tender and potential suppliers were asked to quote for:

2 discrete disk arrays each of 5 terabytes, for Preservation Storage
2 discrete disk arrays each of 1 terabyte, for Workspace Storage
details of solutions for connectivity with existing servers
any other additional software

VSPL Jetstor was selected. The cost was estimated to come out at £9 per effective GB.

This paper reports on the procurement of the technical systems for the large scale storage and preservation of digital objects, including the costs. It also provides the details of the specific institutional context (The British Library) within which these procurements will always sit.

Griffin, Fontaine, Hunolt, Booth, Torrealba (undated)
This paper, issued by NASA's Earth Science Enterprise, outlines a cost estimation tool for the ESE data system. The system is a distributed data and information system to collect, process, catalogue, archive and distribute earth science data.

The tool is based around three related elements:
1) A set of functional areas, including:
Ingest
Product Generation Archive
Search and order
Access and distribution
User support
2) A set of "parameters" for each functional area that provide a quantative description of factors that contribute to costs (i.e. workload, staff effort etc)
3) A set of requirements and levels of service of each functional area.

The report continues to provide breakdowns of the amount of data managed per FTE and the "work" per FTE.

See also: **Zlotnicki (2002)**.

9) Roles and responsibilities

This section of the literature review can be monikered: "Who should do what and why". The issues of who should be responsible for issues within digital preservation are central to LIFE.

Reference Model for an Open Archival Information System (OAIS) (2001)
See page 29 above.

Jones, Beagrie (2001)
See page 25 above

Digital Archive Attributes RLG/OCLC Working Group (2002)
This report builds on the RLG study into the digital preservation requirements of its member institutions and incorporates the OAIS reference model to produce a framework of characteristics of trusted digital repositories. As such, it provides a useful exploration of the roles and responsibilities which exist within digital preservation communities.

Section 1, which provides an overview of what the report defines as Trusted Digital Repositories, discusses some useful scenarios for digital repositories, these include: national libraries collecting on behalf of other memory institutions; large university libraries archiving their own digital content; a museum using a third party service provider; a distributed system for archiving e-journal content (akin to LOCKSS) and a cultural institution with extensive digital holdings which it is legally bound to preserve, which uses a third party service provider for their long term preservation.

There follows a discussion of "trust", the report isolates three types of trust which exist in the digital preservation arena:
1) How cultural institutions earn the trust of their designated communities
2) How cultural institutions trust third-party providers
3) How users trust the documents provided to them by a repository (p9)

The report provides specific recommendations for the attributes of a trusted repository, these can be summarised as: OAIS compliance, administrative responsibility, organizational viability, financial sustainability, technological and procedural suitability, system security, and procedural accountability.

The "responsibilities" section of the report provides an interesting discussion of the curatorial responsibilities of digital materials. These include a recommendation for effective life cycle management and a short discussion of cost factors. These sections make reference to the material cited in this report.

This paper provides a vital combination of the OAIS reference model and a practical base in the memory institutions. Its recommendations provide an excellent perspective on the roles and responsibilities within digital preservation.

Lavoie (2003)
Brain Lavoie provides the most in-depth discussion of the economics, incentives and related areas which this research discovered. He provides detailed sections on economics, incentives and preservation, costs and revenues, incentives to preserve, a simple economic framework and, what it described as an economic tour of digital preservation.

Although the report does not discuss the life cycle of digital information in depth, the concept receives an early mention:
"as digital preservation moves beyond the realm of the small-scale, experimental projects to become a routine component of a digital asset's life-cycle management, the question of how it can be shaped into an economically sustainable process begins to overshadow other concerns." (p ii)

The section on costs provides an accurate discussion of costing of digital preservation which isolates the difficulties, including the lack of empirical data and the large number of variables (period of retention, storage technologies, level of access, objectives of the preservation, preservation strategy, formats, richness of metadata and so on).

Two specific facets of the incentives to preserve are established:
“1: perceived motivation sufficient to induce a party to recognize a need to take action to secure the long-term viability of digital materials in which they are a stakeholder
2: perceived motivation sufficient to induce a party to develop and implement technologies aimed at ensuring the long-term viability of digital materials” (p10)

These facets can be thought of in terms of supply and demand.

The discussion of roles and responsibility within digital preservation occurs within the report’s “simple economic framework”, three principal roles are set out:
Rights holder (holder of the intellectual property)
Beneficiary (all parties who derive benefit from the preserved materials including end users and the memory institutions that they use)
Archive

Interestingly, these roles are mapped to OAIS’s description of the external environment of an archive, with the above roles corresponding to: producer, consumer and management.

These roles are then enumerated as organisational models for archives:
Centripetal (Rights holder, Archive and Beneficiary are the same entity)
Centrifugal (Rights holder, Archive and Beneficiary are all separate entities)
Supply-side (Rights holder and Archive are the same entity; Beneficiary is separate)
Demand-side (Rights holder and Beneficiary are the same entity; Archive is separate)
Consolidated (Archive and Beneficiary are the same entity; Rights holder is separate)

As the author quite rightly states, the above scenarios account for a wide variety of institutional situations, though not all collections will fall neatly into one perspective. The incentives to preserve vary across the above models, with some, demand side, being more obviously strong than others.

The report also contains a rich discussion of the economics around digital preservation. This section proposes that digital preservation “embodies at least three characteristics which could potentially diminish incentives for decision-makers to take the steps necessary to secure long-term retention of digital materials”, these are defined as:
Positive externalities in the digital preservation process
Digital preservation as a public good
Heterogeneous demand, spillover benefits and economies of scale

The report provides an excellent and thought provoking exploration of the economics surrounding digital preservation and gives a useful framework of considerations for those concerned with roles and incentives.

See also**: Council on Library and Information Resources (2003)**

Jones (2003)
Maggie Jones’s paper is the report on the JISC e-journals archiving consultancy which was designed to investigate the feasibility of the archiving clause (2.2.2) of the standard NESLI e-journals license. As such, it provides a useful discussion of the roles and responsibilities surrounding long term access to electronic journals.

Early on in the description of the findings of the study, costs are discussed:
“Costs are not yet well understood, particularly in terms of large-scale digital preservation programmes, but are assumed to be substantial” (p 10).
The issue of preservation incentives is key to this discussion.

There is a discussion of organisational models, which begins by proposing an adaptation to the OAIS model to allow a "wider range" (p 16), of repositories (hosting services, publisher services and so on) there. It then follows a broader description of existing arrangements, including: UK legal deposit, National Library of the Netherlands, NDIIPP (U.S. National Digital Information and Preservation Programme), OCLC digital archive and the JISC academic press agreement. Overall, specific prices are given for these examples.

The report concludes with a series of thirteen recommendations for further work toward providing a reliable archive of e-journal content

This consultancy is a valuable addition to the literature on the roles and challenges within the, very specific, area of archiving electronic journals.

Ayre, Muir (2004)
This report on the rights issues surrounding digital preservation provides some insight into the related responsibility issues. Accordingly, the report states that a "substantial" proportion of the 168 library respondents said that they were "taking or planning to take" some responsibility for digital preservation while still believing that a third party (most popularly a legal deposit library) would take responsibility for the preservation.

There is also a useful enumeration of specific rights issues concerning different preservation strategies.

See also: **Muir (2004)**

Lavoie, Dempsey (2004)
Lavoie and Dempsey provide an enlightening and characteristically strategic view of digital preservation with advocacy for examining roles:
"digital preservation is not an isolated process, but instead, one component of a broad aggregation of interconnected services, policies and stakeholders which together constitute a digital information environment"

and also:
"the focus of digital preservation has shifted away from the need to take immediate action to "rescue" threatened materials, and toward the realization that perpetuating digital materials over the long-term involves the observance of careful digital asset management practices diffused throughout the information lifecycle"

The report closes with a statement very close to the background of the LIFE project, concluding that preserving "digital heritage" is involved with social, cultural, economic, legal issues and involves issues of responsibilities incentives and new forms of curatorial practice.

10) Digitisation projects

There is quite a rich body of literature on the costing of digital imaging projects, this material is useful, but slightly different to the purposes of this report; accordingly this section of the paper is brief.

Puglia (1999)
Puglia provides a breakdown of costs over the stages in the creation and management of a number of digital imaging projects.

Although not defined as such, the life cycle stages across the cost elements are as follows: selection, preparation, metadata creation, preservation/conservation of the physical object, production of intermediates, digitization, quality control of images and metadata, technical infrastructure, on-going maintenance.

The report provides a useful and succinct insight into the life cycles and costs of digital imaging projects and is included accordingly.

University of Michigan Digital Library Services (2001)
This report issued by the University of Michigan digital library services provides an overview of the costs of the digitisation project: “The Making of American IV”. The self confessed primary aim of the project was to examine the costs and the processes involved in the digitisation project, although the digital content that was created was welcome. Accordingly this paper provides useful insights into costs, including analyses of the processes involved and specific costs per page.

Kingma (2000)
Kingma provides a price comparison for hard copy and digital formats coming out of the Early Canadiana Online project.

11) Conclusion

The review has found numerous types of life cycle model, as defined by the LIFE project. Many are directly applicable to the aims and objectives of the project. One thing that is clear from this review is that each specific project adopted its own methodology, to suit its aims objectives as closely as possible.

LIFE aims to provide life cycle costings for electronic library materials; this costing is to include all stages of the life of an item, including preservation. Very few of the costings outlined in this review provide metrics for digital preservation, and the ones that do, approach the problem from a variety of different angles (i.e. Hendley compared to Oltmans). As such, LIFE will synthesise the information above into a new model, generic enough to provide the flexibility to provide costings for different sorts of electronic collections.

Certain points stand out from the research.

First a model should be constructed and then data should be input. Financial data can be gathered in two ways: from the bottom up (assigning tasks, staff times and so on to each stage of the cycle) and from the top down (budgetary and cost centre information analysed in the light of the model selected) and that the appropriate method should be selected according to specific needs.

Costs need to be divided between one time costs and ongoing costs. When considering journals (or for that matter any collection that has title and issue levels) ongoing costs also fall into two varieties: true ongoing costs (for example storage: where if it costs £1 to store an issue of a journal in year 1, you will pay the same amount every year for the same issue), and costs which are one-time but applied to each issue that arrives (if each issue is catalogued you will only do it once per issue, but different issues arrive four times every year).

It is useful to provide a generic model which can be applied to multiple collections, with stages assigned a zero cost if necessary.

There is a need for cost metrics for digital preservation within a life cycle costing context. Although it is true that until multiple archives have gone through multiple digital preservation actions (e.g. migrations) there will be no data to base there will be no concrete data on which to base this stage of the process, there is still a demand for work to inform what is likely to happen.

Appendix A

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Appendix C

This appendix is a reproduction of the conceptual "life cycle stages" as they are listed above in the various reports and papers.

<u>This information was reproduced in this format to provide a quick reference guide to stages when the LIFE model and methodology was constructed.</u>

Life cycle models

1.)
Life cycle stages as set out in the **Terotechnology handbook (1978)**, developed as a technique for the costing of physical assets:

Acquisition (of physical assets)
- Specification phase
  - The cost effectiveness of the asset's characteristics (performance, reliability, safety and perhaps non-material features such as appearance)
  - Cost effectiveness of individual components and sub-systems and their contribution to the value of the physical asset as a whole
  - The cost effectiveness of all cost elements of each phase over the life-span of the physical asset
- Sale and purchase phase
- (also mentions: acquisition, installation and commissioning, operations and maintenance, maintainability, reliability, availability and downtime, disposal)

The operational life (of physical assets)
- Maintenance
- Operational management of physical assets
- Disposal of physical assets

2.)
Although **Dugan**'s **(2002)** focus is IT hardware and software infrastructure, he does mention that his methodology can be applied to Information Resources as well:

Investigation
Negotiation
Acquisition
Installation
Training
Maintenance
Evaluation
Upgrade, Migrate, Replace or Abandon

3.)
Stephens (1988) defined formulas for monographs and for serials, with the persistent effort for receiving and processing each issue of a serial causing the difference.

For monographs:
K(t)=s+l+a+c+pl+p(t)+ht
For serials:
K(t)=s+lt+c+at+plt+hlt+p(t?)+ht?

Where:

s is the cost of selection
l is the literature cost
lt is the cost of subscription for t years
a is the accession acquisition and processing cost
c is the record creation cost
pl is the initial preservation cost
at is cost of accessioning t years' issues

p(t) is the depreciated long-term preservation cost to be incurred during the period t
plt is the cost of preserving t years' issues
hlt is the first handling cost for t years' issues
ht= the storage cost, which is linearly related to t
p(t?)= the likely preservation cost to be incurred by each issue during the period t
ht?= the storage cost for each of the issues received during the period t

(n.b.: t?= terminal i.e. 1+2+3…+t)

4.)
Hernon (1994) provides a synopsis of the US information policy instruments and their take on life cycles:

Information Creation and Gathering
Production, Processing and Publication
Transmittal (Access, Dissemination and Distribution)
Retrieval and use
Retention (Storage and Archiving) and Disposition

5.)
Montgomery, Sparks (2000) provides an enumeration of the cost elements of the management of journals, both printed and electronic, in an academic library environment:

Circulation/Access
- Re-shelving
- Stack maintenance
- User photocopying
- Collecting use data

Reserve
- Article file maintenance
- Article checkout
- Maintaining e-reserves

Technical Services
- Print journal check-in
- E-journal acquisitions
- Claiming
- Binding
- Cataloging print
- Cataloging e-journals
- Catalog/e-journal list maintenance
- Print subscriptions
- Electronic subscriptions

Information Services
- Reference at desk
- Instruction/Promotion
- Preparing documentation
- Journal selection

Document Delivery
- Faculty copy service
- Interlibrary loan - Borrowing

Systems
- Infrastructure purchase
- Infrastructure maintenance

Negotiating contracts
Setting up access
Developing decision support tools
Collecting use data
Printing

Space Utilization
Occupying space

Administration
Managing the change
Attention to decisions
Budgeting

6.)
The **Connoway, Lawrence (2003)** paper presents a methodology to define generic stages and sub-stages within the life cycle of the resource:

Selection
Jobber list maintenance
Review jobber submissions
Patron request
Bibliographer recommendation
Receive gift
Acquisition
Purchase monograph
Receive
Process gift
Ship returns
Cataloging
Authority control
Catalog
Classify
Maintain database
Maintenance
Bind
Mark
Secure
Bar code
De-acidification
Mend and repair
Circulation
Shelve / reshelve
Store in stacks
Checkout
Convert
Trace
Recall
Overdue
Return
Process lost book
Issue fines notice
Collect fines
Reading / viewing areas
Warehousing / storage
Identify
Update database
Mark

Move
Store
Retrieve / return

Deselection
Identify
Update database
Retrieve
Pack
Ship
Dispose

7.)
After Stephens' second paper (1994), a further development was made by **Shenton (2003)**, with stages similar to those established earlier:

The Monograph life cycle costs are defined by Shenton as:
K(t)=s+a+c+pl+hl+p(t)+cs(t)+r(t)

The Serial life cycle costs are defined as:

K(t)= s+at+c+plt+hlt+p(t?)+cst?+rt?

Where
K(t) is the life cycle cost
s is the selection cost
a is the acquisition processing cost (excluding the purchase price)
c is the cataloguing cost
pl is the initial preservation cost (such as an archival enclosure)
hl is the initial handling cost (including pressmarking, labelling and placing)
p(t) is the likely preservation cost over time (including interventive conservation)
cs(t) is the collection storage cost over time
r(t) is the likely retrieval and replacement cost over time

The model below was applied to the British Library's "Digitised Masters":

K(t)=s+ipr+cons+r+cap+q+m+acs(t)+p(t)

ipr= the cost of checking the ipr
cons= is the conservation check and remedial conservation costs
r= the retrieval and reshelving costs
cap= the capture of the digitised master
q= is the cost of quality assurance of digitised master and production of service copies
m= the metadata creation cost
acs(t)= the access cost over time
p(t)= the preservation and storage costs over time

8.)
Schonfeld, King, Okerson, Fenton (2004) report for the Council of Library and Information Resources, proposing an inventory of cost stages, which together form the life cycle of the digital resource:

Print:
One year:
All staff costs on the current issue format
Staff costs for those activities on the backfile format that are one-time in nature, namely:
Collection development
Licensing and negotiation
Subscription processing, routine renewal and termination

Receipt and check in
Routing of issues and/or TOC
Cataloguing
Linking services
Physical processing

Depreciation of staff workstations, allocated on the same basis as the staff costs
Total cost of binding
Total cost of subscription agents
Cost of space occupied by the current issues reading room during the year

Ongoing
Staff costs on the backfile format for ongoing services, calculated on a dollar-per-year basis, namely:

Stacks maintenance
Circulation
Reference and research
User instruction
Preservation
Other activities

Depreciation of staff workstations, allocated on the same basis as the staff costs
Depreciation of publicly available workstations, allocated at 2% to print periodicals
Annual cost of storage space in an off campus facility, calculated on a dollar-per-year basis
Annual cost of shelving, calculated on a dollar-per-year basis

Therefore: the print life cycle cost= 1*(One time cost per title) + Net present value of 25 years of [(Bindings per title)*(Annual ongoing cost per volume)]

Electronic:
One year:
Staff costs for those activities that are effectively one-time in nature, namely:

Collections development
Receipt and check in
Cataloging
Linking services

An allocation of staff time costs for two activities that are principally (we estimate 75%) one-time in nature but have recurring components to them as well

75% of negotiating and licensing
75% of preservation processing

The depreciation of staff workstations, allocated on the same basis as the staff costs

Recurring (that don't vary by usage):
Staff costs for those activities on the electronic format that are effectively recurring, unrelated to usage, in nature:

Routing
Preservation
Other activities

An allocation of staff costs for two activities that are principally (we estimate 25%) one-time in nature but have recurring components to them as well:

25% of negotiations and licensing
25% of subscriptions processing

Depreciation of staff workstations, allocated on the same basis as the staff costs

Some costs vary as the amount of usage:
Staff costs for those activities on the electronic format that are effectively recurring, related to usage, namely

Circulation
Reference and research
User interaction

The depreciation of staff workstations, allocated on the same basis as the staff costs
The depreciation of publicly available workstations, allocated at 6% to electronic periodicals

Therefore: Electronic Life-Cycle cost= 1*(One time cost per title)+ Net present value of 25 years of (Annual ongoing cost per title)+1.21* use related cost per title)

[It's 1.21 because: "Recent surveys in three universities suggest that there is only about 21% more use beyond the five years"]

In stage 13, the following stages are defined:

Preservation
- Conservation and repair
- Preservation microfilming
- All preservation and archiving associated with electronic periodicals
- Disaster recovery planning and activities

This approach allows one tool to be applicable to multiple collections of varying formats.

9.)
King, Aerni, Brody, Herbison, Kohberger (2004) provides an insight into the differences involved between electronic and paper collection processes:

Five service components are defined:
collections-related component (licensing and negotiations, acquisitions etc)
backfile-related component (binding etc)
user-related components (instruction, faculty liaison etc)
use-related component (reference, bibliographic search etc)
support-related component (systems development etc)

These costs are then defined as fixed, variable or marginal and either direct or indirect.

The cost of a collection item = the annual cost + the life cycle cost (where the life cycle cost is defined as the same as Schonfeld et al above).
Set out below is their sixty-seven point data collection plan:

Reference and Research (For all formats including microforms)
1. Directional/ Access Questions
2. Access questions that require going off the desk (compact shelving/assistance in stacks) including responses to search requests from patrons
3. Reference (brief- five minutes or less)
4. Reference (in-depth- more than five minutes)

Online Bibliographic Searching
5. Quick look up on OPAC (one minute or less)
6. In-depth on OPAC (more than one minute)
7. Quick look-up using other databases
8. In-depth with other databases

Circulation and Use
9. Circulation work including recalling of overdue materials.
10. Physical withdrawal activities, such as collection shifting
11. Shelving, re-shelving and shelfreading of current periodicals
12. Shelving, re-shelving and shelfreading of bound volumes
13. Shelf maintenance, i.e.- labeling shelves/ranges

Serial Processing
14. Create and route journal lists
15. Maintaining route lists
16. Serials check-in using Voyager (for the currently received issues)

17. Identify and make changes to current issue display (includes addition of notes and setting up or changing check-in patterns)

Interlibrary Borrowing, Lending and Storage

18. Interlibrary borrowing (external resources, i.e.- from outside of ULS system)
19. Interlibrary borrowing (internal resources, i.e.- from within ULS)
20. Interlibrary lending (external), i.e.- delivery of items from document delivery services
21. Interlibrary lending (internal), i.e.- photocopying, printing resources for outside requests.

User Instruction

22. Conduct tours and/or present briefings
23. Prepare for tours/ briefings
24. Conduct training sessions/demonstrations
25. Other user instruction
26. Creation of resources/ guides

Collection Development and Management

27. Review and select approval materials as well as materials form slips, catalogs and other ordering tools.
28. Review and decide on materials from Gift & Exchange; or received directly in departmental libraries
29. Collection weeding, including transfer of journals to remote storage
30. Collection analysis and work with collection reports (including vendors, in-house)
31. Identify and place orders for missing/lost issues

Acquisitions

32. Order new subscriptions, including selection and download of bibliographic record, verifying title information on vendor's website and creating the purchase order.
33. Order and receive journal back-orders
34. Direct communication with Vendors and publishers other than Voyager claiming (i.e., asking for invoice information, canceling orders, etc)
35. Communicate with vendors and publishers regarding electronic access problems.
36. Receive, verify and return vendor quotes for subscription renewal.
37. Set up vendor information in Voyager
38. Post invoices from vendors and publishers in Voyager via Elect, Data Interchange or manually.
39. Verify and approve payments in Voyager and complete invoice data transfer to Accounts Payable.
40. Investigate invoice payments for vendors, publishers and ULS staff.
41. Clear suspense file of invoices upon receipt of monthly PRISM levels.

Materials Receiving and Mail Processing

42. Mail and materials processing (for example, opening the mail and delivering first class mail, opening, sorting and delivering library materials).
43. Serials delivery to campus (preparing bins, boxes, etc.)

Cataloging

44. Copy and enhanced cataloging for new serials and for title changes, cessations, etc.
45. Original cataloging for new serials and for title changes, cessations, etc.
46. Perform authority control functions on records (name and subject heading corrections)

Catalog Maintenance

47. Create and update volume holdings in Voyager
48. Report holdings and check in errors (public services staff)
49. Voyager withdrawal activities (location information and last copy withdrawal)
50. Union listing activities with OCLC

Physical Processing & Preservation

51. Spine labeling, barcode labeling/linking, tattletaping for classed items
52. Periodical stamping, marking and tattletaping + any other activities of this type
53. Periodical binding and repair
54. Disaster recovery planning and activities

Other Support Functions

55. Maintaining statistics
56. Making photocopies for users
57. Faculty Liason Service
58. PC support and troubleshooting
59. Software/ Website programming
60. Server support
61. System Administration
62. Digitization work
63. Vendor interaction, including licensing
64. Creation and update of procedural manual for job descriptions

Other work activities

65. Break/ Slack time (coffee breaks, etc)
66. Email correspondence
67. Vacation, sick leave, and holidays
68. Professional development and training, including conferences and meetings

10.)
Greenstein (1997) proposes a life cycle for best practice of digital information, including:

Data creation
Data selection and evaluation
Data management
- Data structure (i.e. how it is formatted, compressed and encoded)
- Data documentation
- Data storage (i.e. where is it off-line, near line, on the web or stored locally)
- Data validation (assessment, copying, media refreshment)

Resource disclosure
Data use
Data preservation
Rights management

NB: rights management is not defined as not a stage in the life cycle, but rather a description of a consideration that needs to be made at every stage of the life cycle.

11.)
Beagrie, Greenstein (1998) expand upon Greenstein's 1997 work, aiming to define a framework for managing digital resources which will aid the creation, management and preservation of digital resources:

Data Creation
Data Collection Management and Preservation
- Acquisition, Retention or Disposal
- Data management
- Data structure, format, compression and encoding
- Data description and documentation
- Data storage
  - Periodic checks of completeness
  - Refreshing the storage medium

Migrating the resource onto new storage media or new formats
Provision of contingency copies
Retaining a copy of the resource in its primary format
Data preservation (migration, technology preservation, emulation)
Data use
Rights management

12.)
Hendley (1998) developed a cost model, achieved by taking Greenstein's framework, analysing each element within the framework and assigning a cost to each element. This figure would then be reduced according to how much specifically related to preservation. To achieve this pragmatically, Hendley took the elements within the following seven modules:

category of digital resource
creation
management prior to deposit
deposit
documentation
validation
data use/rights

He then identified which generic elements related specifically to preservation:

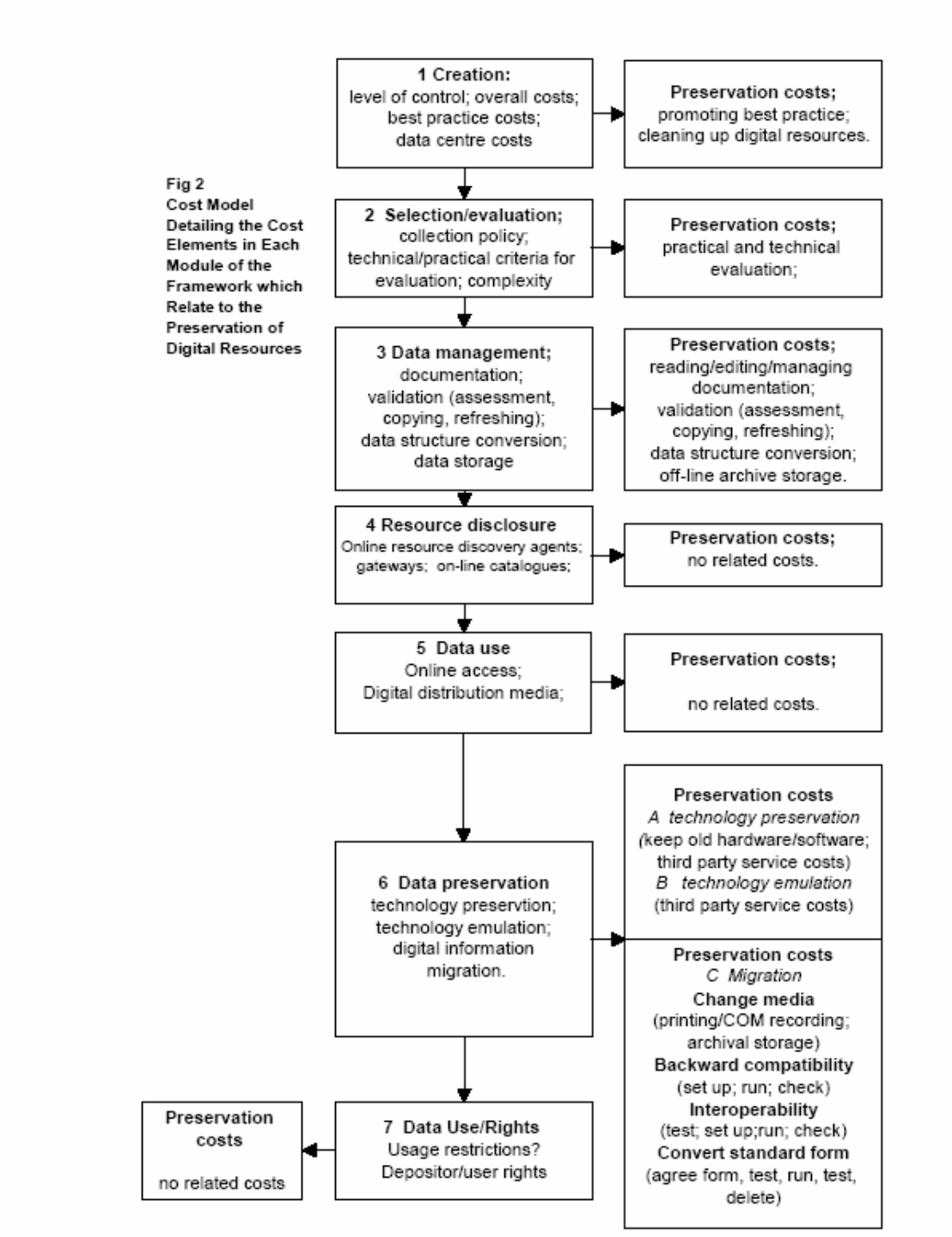


Fig 2
Cost Model Detailing the Cost Elements in Each Module of the Framework which Relate to the Preservation of Digital Resources

13.)
Feeney (ed) (1999) brings together the series of publications from JISC and the NPO on digital archiving, with a concise but valuable summary of the “strands” within digital preservation, highlighting issues of:

Stakeholders – including rights and responsibilities
The different stages in the life cycle
Techniques of digital preservation
Evaluating digital resources to select the appropriate strategy
Identifying and estimating costs
Management of risk and rescuing digital resources

14.)
Hodge, Carroll (1999) advocate a life cycle approach to digital archiving. The model takes the framework suggested by Greenstein and Beagrie and adapts it slightly:

Creation
Acquisition and collection development
- Collection policies
  - Selecting what to archive
  - Determining extent
  - Archiving links
  - Refreshing the archived contents
- Gathering approaches
- Intellectual property concerns

Cataloguing and identification
- Metadata
- Persistent identification

Storage
- Hardware and software migration
- Refreshing the media
- Backup and recovery

Preservation
- Refreshing the site contents
- Retention
- Standards, Transformations vs Native Formats
- Preserving the look and feel

Access
- Access mechanisms
- Rights management and security requirements

15.)
The **Jones, Beagrie (2001)** handbook provides “pointers…and guidance aimed at encouraging good practice in creating and managing digital materials”:

Creating digital materials
- Creating digital surrogates
- Creating electronic records

Acquisition and appraisal, retention and review
- Appraisal and selection
- Retention and review
- Accessioning
  - Transfer procedures and guidelines
  - Procedures to prepare data and documentation for storage and preservation
    - Unique numbering
    - Preferred marking and labelling
    - Handling guidelines
    - Validation
      - Scanning for computer viruses
      - Checking media and files can be read
      - Checking completeness and accuracy of documentation
      - Checking description and intellectual content of the resource
      - Checking structure and formatting of resource
      - Procedures for documenting validation checks
      - Procedures for checking and resolving discrepancies with the supplier
    - Re-formatting file formats
    - Re-formatting storage media
    - Copying

- Security
- Cataloguing and documentation Procedures
  - Cataloguing
  - Retrospective documentation or catalogue enhancement
  - Edition and version control
  - Cataloguing and documentation standards
  - Processing times
- Storage and preservation
  - Storage and maintenance
    - Storage media and file formats
    - Management of media and systems
      - Media refreshing and reformatting
      - Disaster recovery planning
      - Environmental conditions
      - Care and handling
      - Audit
      - Security
      - Management of computer storage
  - Preservation strategies
    - Primary preservation strategies
      - Migration
      - Emulation
    - Secondary preservation strategies
      - Technology preservation
      - Adherence to standards
      - Backwards compatibility
      - Encapsulation
      - Permanent identifiers
      - Converting to stable analogue format
      - Digital archaeology
- Metadata and documentation
  - Metadata
  - Documentation
    - Technology
    - Change
    - Rights management
    - Continuity
    - Accountability
    - Authenticity
    - Cost
    - Feasibility
    - Future
- Access
  - Storage and security
  - Legal
  - Media
  - Technical

16.)
Muir (2001) summarises issues as part of the context behind the legal deposit of digital materials, covering the following broad areas:

identification
selection
acquisition
accession and processing
preservation
access

The concept of life cycles is referred to as a “tool for looking at the challenges of digital preservation” (p 667):

resource creation
resource selection and evaluation
resource management
resource disclosure
resource use
resource preservation
rights management

There is also a discussion of costs for digital preservation:

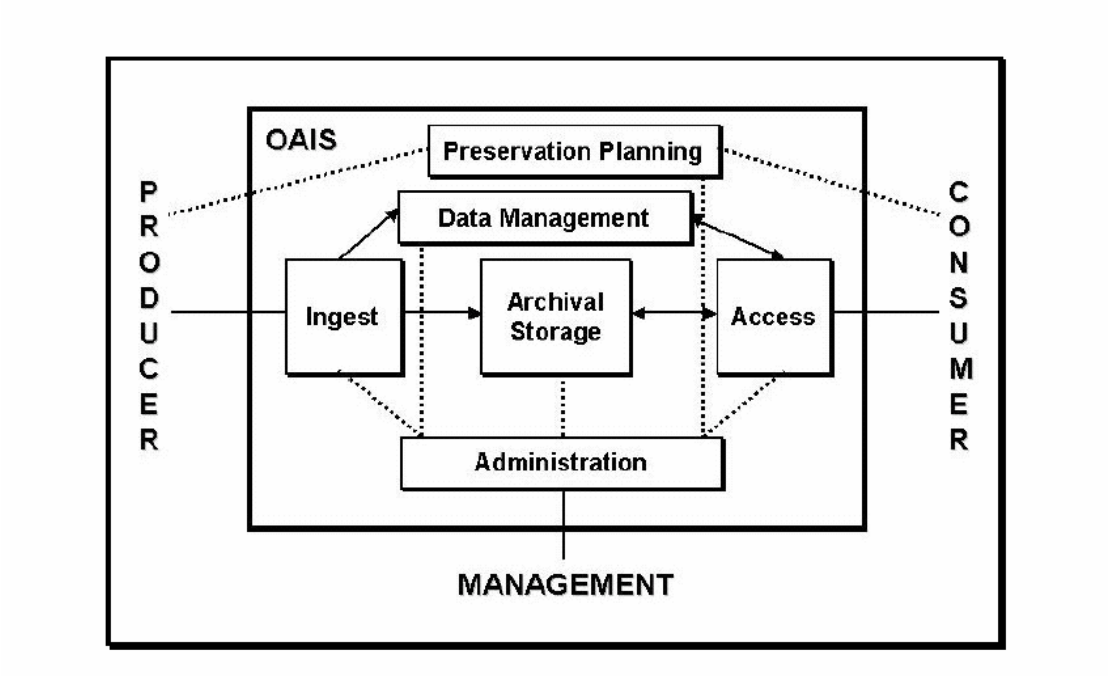
define the key tasks involved in digital preservation;
review the three preservation strategies – migration, emulation, technology preservation – given in the study remit;
define all the digital information resources and data types covered by the study;
develop a decision model to assess categories of digital resource and select the most appropriate preservation strategy; and
develop a cost model to assess costs according to category and preservation strategy and also to allocate costs to the stages in the management process

17.)
Reference Model for an Open Archival Information System (OAIS) (2001) defines the roles and responsibilities within a system as follows:

• Compliance with the Reference Model for an Open Archival Information System (OAIS)
• Administrative responsibility
• Organizational viability
• Financial sustainability
• Technological and procedural suitability
• System security
• Procedural accountability

The reference model also defines a high level functional model:

Ingest
Archival storage
Data management
Administration
Preservation planning
Access



[this picture came from p8 of the DPC intro to OAIS]

18.)
Ockerbloom's **(2002)** report provides a useful breakdown of the possible organizational models that it perceives within digital preservation:

Self archiving [i.e. akin to an institutional repository]
Integrated responsibility [i.e. akin to a traditional library's print function]
Distributed responsibility [i.e. akin to LOCKSS]
Service providers [i.e. akin to a 3rd party preservation service such as ULCC]
Registries

Closely related to this is the discussion of "archival rights and responsibilities", which breaks down individual stages within the life cycle of an archive and seeks to assign responsibility for these stages:

Responsibilities for selection
    i.e. who chooses
Responsibilities for ingestion
    i.e. who assigns what metadata
Rights and responsibilities for storage and maintenance
    including who is responsible for migration/emulation of content etc
Rights and responsibilities for access and distribution
    who decides what should be available to who and how
Rights and responsibilities for access and distribution
    who decides what should be available to who and how

Following on from this discussion, the report discusses what it calls the "archival life cycle":

Ingest
Archival storage
Data management
Administration
Preservation planning
Access

19.)
The **Harvard University Library (2002)** report to the Mellon foundation on its e-journal archiving activities:

Ingest
- SIP
  - Submission session
  - Quality assurance
  - Descriptive information
  - Transformation of SIP to AIP
- Data management
  - Bibliographic control
  - Naming (i.e. persistent identifiers)
- Archival storage strategy (i.e. RAID discs etc)
- Preservation strategy
  - Preservation strategy
  - Levels of preservation service
  - Policy implications
- Access
- Administration

Schedule (i.e. what to test and review and when)

The report concludes by isolating the following roles and responsibilities:

Internal roles and responsibilities:
- Technical development
- Archive content development
- Curatorial responsibilities

External:
- Stakeholders
- The archival community
- Sharable infrastructure

20.)
The **Yale University Library and Elsevier Science (2002)** report provides a useful discussion of “trigger events” which would mean that a publisher would turn content over to an archival agent:

loss of access or abdication of responsibility (i.e. publisher goes bust etc)
lapse of a specific period of time (i.e. JSTOR)
on site visitors
archival uses
metdata uses

The report proposes the following “life cycle cost stages of an e-journal archive”:

The difficult part (development and startup)
The easier part (ongoing maintenance and problem resolution)
The tricky part (collaboration and standards)
The messy part (comprehensiveness)
The part where it becomes difficult – and probably very expensive – again (migration)

The report goes on to discuss models for the funding of an archive:

Up-front payment
Ongoing archival fees
The traditional library method
Fee for services operation

Hybrid (i.e. an amalgam of the above)

The Yale report also isolates the following issues which would occur within the use of an archive of e-journals:

Selection and appraisal
Preservation of structural information
Guaranteeing authenticity

21.)
Sanett (2002) identifies three cost categories for preservation activities: costs for preserving electronic records, costs for use and user populations. These costs are as follows:

Costs for preserving electronic records

Part 1, capital costs
- Software development
- Hardware (for preservation processing)
- Research and development
- Facilities
- Interface design for processing electronic records

Part 2, direct operating costs
- Identify potential records
- Evaluate/Examine (negotiate IPR)
- Acquire records (staff and purchase or royalty payment)
- Establish Inventory Record
- Process (prepare for preservation, confirm authenticity/integrity of record)
- Produce metadata
- Preserve (select and implement appropriate stategy)
- Storage (container/other)
- Maintenance (refresh/migrate)
- Monitor
- Evaluate

Part 3, indirect operating costs (overhead)
- Indirect staff (supervision, clerical support, benefit times, training times, unallocated times)
- Facilities (rent, utilities, off-site storage of records))
- Amortization of capital costs
- General and administrative (hr, accounting, funding development and grant writing, staff training and professional development, partnerships with other institutions policy development)

Costs for use of preserved electronic records

Part 1, capital costs for use
- Equipment, software, user training, facilities, interface design etc

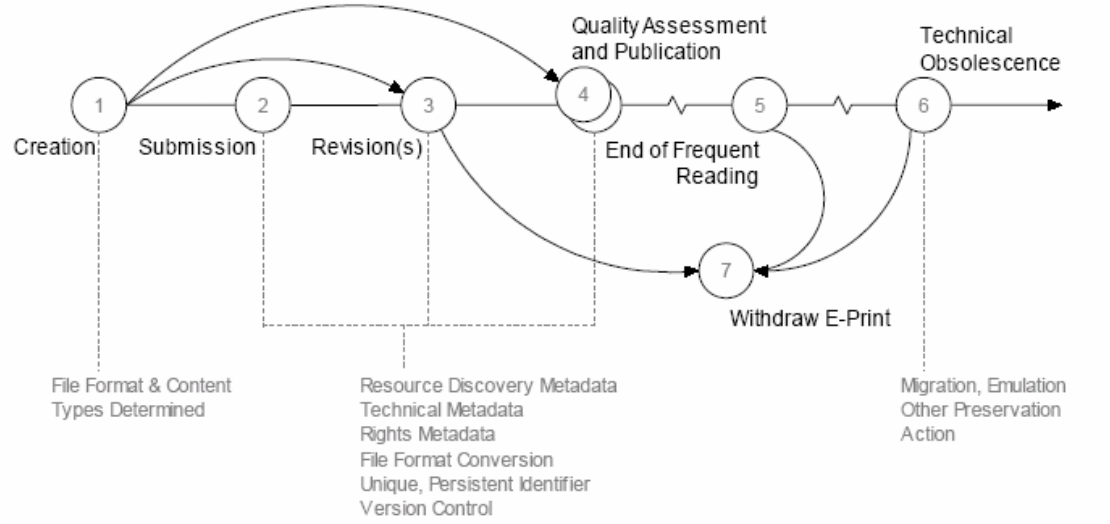
Part 2, direct operating costs for use
- Storage, royalties, communications, records access mechanisms.
- Staff for monitoring, user query response and services, records access management

Part 3, indirect operating costs for use
- Indirect staff, facilities, amortization of capital costs

Notes on the above:

i) Capital costs for preserving records are costs incurred at the beginning. They must be amortized over a time period such as 5 years, which can then be used as the period for present value calculations
ii) Indirect and direct operating costs for Preserving Electronic Records are costs incurred on a yearly basis. They should be brought to Present Value (the value now of money expected to be received in the future). The period of 5 years is suggested because the magnitude of the investment in hardware and software is great enough to justify replacing at five years rather than earlier.
iii) The sum of i) and ii) together are the total costs for Preserving Electronic Records brought to present value. The cost per item preserved is i+ii/(total number of items preserved).
iv) Operating costs for the use of Preserved Electronic Records are incurred on a yearly basis. These costs should be brought to present value.
v) The sum of iii) and iv) is the total present value for preservation and use of electronic records. The cost per use is iii+iv/(Total use of electronic records over five years (or the period used for present value calculations).).

22.)
James, Ruusalepp, Anderson, Pinfield (2003) reproduce a schematic of the typical life cycle of an e-print:



The report discusses the cost elements isolated by the CEDARS project; however, these costs are deemed likely to be insignificant to the costs associated with:

negotiating rights
managing proprietary file formats
cost of creating additional metadata (especially technical and administrative)

The investigation defines “e-print life cycle cost elements” which are the costs as related to the events in the schematic above, these are:

submission and revision (costs surrounding comparison with collection policy)
publication (retention or removal at publication elsewhere)
retention assessment (retention or removal on some form of value assessment over time)
technical obsolescence (decisions as to whether to emulate, migrate etc)

23.)
Hodge (2004) provides a discussion of common workflows, stages are defined as follows:

selection
ingestion

metadata creation
archiving and transformation
storage
dissemination

Within these stages there are some secondary steps discussed.

24.)
Phillips (2005) adopts a life cycle methodology to the allocation of costs across the acquisition of “instances” of the harvested websites.

Cost drivers were established and defined as:

identification and selection;
publisher contact (i.e. permissions);
gathering, quality assurance and archiving;
cataloguing; other activities;
partner liaison and support.

The relevant data was then extracted.

Costs were established as: staff cost per instance: AUD$168.36, supplier costs: AUD$3.41 and infrastructure development: AUD$6.91. Within these costs the “drivers” (or life cycle stages) were costed at the following levels: identification and selection:
publisher contact (i.e. permissions): AUD$10.16
gathering, quality assurance and archiving: AUD$10.34
cataloguing; other activities: AUD$27.42 (or AUD$59.67)

25.)
A useful guide to the arena of life cycles within records management is provided by the **Public Record Office (1999)**:

Capture (creation and addition into an information management system)
Disposition (a decision on the retention period for the record)
Appraisal (process of making decisions on initial disposition and final disposal)
Preservation (migration through technologies etc)
Disposal (discard or transferral to a permanent archive)

26.)
Ashley (2000) demonstrates that prices per bit are dependent on the specific situation of an particular digital archive and are therefore not reliable for generally applicable cost models.

He does propose some variables which will affect price:
How many items?
How big are they?
How do they vary?
Who can access them?
How often, how quickly, will access occur?
What control do you have?
What descriptions are required?
Do resources arrive in neat bundles?
Is metadata attached?
Selection by policy or individual appraisal?
Is access random or to bundles of objects?
Must non-digital sources sources also be acquired?
Is material current or obsolete?
Was archiving considered in the application?

What is the service model?

27.)
Russell, Weinberger, Granger (2000) propose a conceptual taxonomy of archives:

Simpler
Lower cost
archive

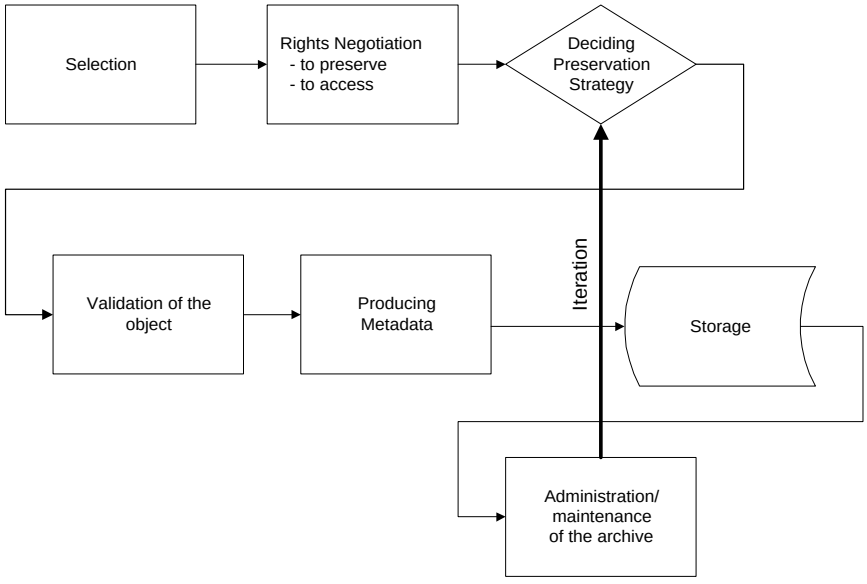
More complex
Higher cost
Archive

Data types & formats	Limited number.	Large number.
Rights	Ownership	Non-ownership
Control	High degree of control	Low degree of control

The cost elements which are isolated are as follows:

Selecting a particular digital object for preservation
(taken by collection managers and systems managers)
Negotiating the right to preserve the object
Negotiating the right to provide access to the preserved object
Determining the appropriate technical strategy for preservation and continuing access
Validating the completeness of the object on delivery to the archive
Producing metadata
Storing files
Administering the archive

This is also represented as a chart:



28.)
CEDARS Guide to digital collection management (2002) provides a discussion of the life cycle of a resource. The full breakdown of costs runs as follows:

Upfront costs
- Establishment or enhancement of digital archive infrastructure
  - This will also be ongoing to keep systems up to date
- Selection of materials for archiving
- IPR issues
  - This will also be ongoing
- Consideration of continues access to the object over time
- Validation of integrity
- Preservation medadata

Long term or on-going costs:
- File storage
- Archive administration
- Evaluation and revision

Costs that are likely to vary over time:
- Technical Strategies for continuing access
- Medadata production costs
- Rights negotiation costs [according to whether:]
  - National libraries reach agreements with publishers
  - Standard licenses are available which allow digital preservation
  - An exception to the EU copyright is passed
  - LDEP is introduced

Also relevant is the report's analysis of the necessary collection management policies. These are recommended for the following stages:

Selection of materials
- Archived
- Served
- Mirrored
- Linked

Acquisition and organisation of materials within the collection
- Receipt
- Verification of the object's integrity
- Decisions regarding the long-term role of the material within the collection, including the assessment of the object's significant properties
- Cataloguing (including the assignment of unique identifiers and other preservation metadata)
- Classification within the collection
- Provision of discovery aids (e.g through OPAC)
- Provision of Access to the material
- Application of appropriate access controls and security
- Consideration of actions necessary for ensuring the object's long term preservation (e.g. conversion of materials to designated archiving formats as detailed in a collection management policy)

Storage and access to materials
- Preservation and continuing access
- Storage of archived materials
  - How materials are moved from acquisition to permanent storage
  - How the storage hierarchy is managed and by whom
  - How the storage media are refreshed and how often
  - How objects are to be disseminated from the repository
  - Disaster recovery, including:
    - Rolling program of media refreshment
    - Geographically distributed management systems

Access to materials
Digital preservation strategies and library policies
De-selection and reformatting

29.)
Crespo, Garcia-Molina (2001) provide an insight into the estimation of costs in an archival repository. A set of cost "sources" is proposed which go toward building the cost events:

Hardware and software
Non-labour operational costs
Labour costs
Information acquisition
Insurance
Unavailability
Cost of losing a document

These sources build the following events:

AR Creation
Document access
AR operation
Failure detection
Repairs
Preventive maintenance
Upgrades

30.)
Electronic Publishing Services (2002) isolated the following stages:

Selection
Accessions
Cataloguing
Storage and preservation
Metadata
Access
Other technology costs
Management

More information is given by the report about the intricacies within the above stages.

31.)
Hodge (2002):

- Creation
- Acquisition and collection development
  - Collection policies
    - Selecting what to archive
    - Determining extent
    - Archiving links
    - Refreshing the archived contents
  - Gathering approaches
  - Intellectual property concerns
- Identification and cataloguing
  - Metadata
  - Persistent identification
- Storage
- Preservation

Hardware and software migration
Preservation of the look and feel
Transformation vs. Native Formats
Standards and interoperability

Access

Access mechanisms
Rights management and security requirements

33.)
Erpanet, Cost orientation tool (2003) provides a matrix of factors which will have an impact on cost:

Objects
- Influence on creation
- Existing
- Complexity
- Preservation period
- Appraisal/value

People
- Skills
- Quality
- Training
- Experience

Standards
- Standards

Practices
- Workflow
- Operation
- Processes

Systems, methods and technologies
- Preservation method
- Validation method
- Sustainability
- Portability
- Components
- Maintenance
- Operation
- Flexibility
- Facilities
- Class of preservation
- Modularity

Law and policies
- Legislation
- Policy

Organisation
- Relationship building
- Capacity building
- Responsibilities

34.)
Oltmans, Kol (2005)

$K(t,a)=s(a)+i(a)+h(t,a)$
Where $K(t,a)$ is the total cost of handling a objects for a period of t years, where s=selection, i=ingest and h=storage

Migration
$K(t,a)=h(t,a)+m(t,a)$

Where K(t,a) is the total cost of holding a objects for a period of t years, where h=storage costs and m=migration costs

“A new variable is introduced that expresses the costs of migrating an object. The costs of migrating digital objects is dependent on the time t (the longer we preserve the objects, the more often we have to convert them) and on the number of objects a (the more objects in the archive, the more conversions have to be executed)”

Emulation:
K(t,a)=h(t,a)+E+e(t)

Where K(t,a) is the total cost of handling a objects for a period of t years, where h=storage costs, E=costs of setting up the emulation virtual machine, and e(t)=costs of emulation over time.

“Two new variables are introduced. The one time costs for developing an emulation device are expressed by E, while yearly maintenance of the emulator are expressed by e. Maintenance costs and costs for the development of emulation tools are independent of the number of objects: the emulation device and other emulation tools apply to the entire collection, and no special action is needed when rendering an object in the digital archive. However, the emulation tools need to be maintained over time, which makes the maintenance costs dependent on the number of years.”

35.)
Griffin, Fontaine, Hunolt, Booth, Torrealba (undated) outline a cost estimation tool based around three related elements:

1) A set of functional areas, including:
Ingest
Product Generation Archive
Search and order
Access and distribution
User support
2) A set of “parameters” for each functional area that provide a quantative description of factors that contribute to costs (i.e. workload, staff effort etc)
3) A set of requirements and levels of service of each functional area.

The report continues to provide breakdowns of the amount of data managed per FTE and the “work” per FTE.

36.)
Reference Model for an Open Archival Information System (OAIS) (2001) defines a high level set of mandatory responsibilities; an OAIS archive must:

• Negotiate for and accept appropriate information from information producers
• Obtain sufficient control of the information in order to meet long-term preservation objectives
• Determine the scope of the archive’s user community
• Ensure that the preserved information is independently understandable to the user community, in the sense that the information can be understood by users without the assistance of the information producer
• Follow documented policies and procedures to ensure the information is preserved against all reasonable contingencies, and to enable dissemination of authenticated copies of the preserved information in its original form, or in a form traceable to the original
• Make the preserved information available to the user community

37.)

Digital Archive Attributes RLG/OCLC Working Group (2002) proposes a reliable digital repository that:

- Negotiates for and accepts appropriate information from information producers and rights holders;
- Obtains sufficient control of the information provided to support long-term preservation;
- Determines, either by itself of with others, the users that make up its designated community; that is, that the community can understand the information without needing the assistance of experts;
- Ensures that the information to be preserved is 'independently understandable' to the designated community; that is, that the community can understand the information without needing the assistance of experts
- Follows documented policies and procedures that ensure the information is preserved against all reasonable contingencies and enables the information to be disseminated as authenticated copies of the original or as traceable to the original
- Makes the preserved information available to the designated community
- Works closely with the repository's designated community to advocate the use of good and (where possible) standard practice in the creation of digital resources

38.)
CEDARS Guide to intellectual property rights (2002) makes the following recommendations with regard to the roles within the preservation of digital library material:

- Preservation should be organised on a collaborative basis
- CURL libraries should be involved in the collaborative procedure
- Institutions should manage at least the digital objects they create
  some institutions will need to manage the digital resources they acquire, at least for the short to medium term and/or until a reliable model for long term preservation is established
- Ultimately, a relatively small number of trusted digital repositories will undertake long-term preservation on behalf of a larger number of stakeholders

39.)
The **Council on Library and Information Resources (2003)** isolates sections for considering "Preservation from an Economic Perspective: Three key areas":

Responsibilites

Incentives

Organization

40.)
James, Ruusalepp, Anderson, Pinfield (2003) identify stages of cost (taken from CEDARS):

Selection
Negotiation
Technical strategy for preservation and access
Validation
Metadata
Storage

They also speak of the taxonomy of archives:

	Simple low cost archive	Complex, high cost archive
Data types/formats	Limited number	Large number

Rights	Ownership	Non-ownership
Control		Full metadata

Also, under the life cycle cost elements section (chapter 9.4), the following table is presented:

E print repository scenario	Submission (including revision)	Publication		Use assessment		Technical obsolescence		
	Accept/reject	Retain	Remove	Retain	Remove	Migrate	Remove	retain
Preferred format with complete metadata set	Low	Low	Med	Low	B=Low M=Med	Low	Low	Deferred cost-high
Preferred format with incomplete metadata set	Med	Low	Med	Low	B=Low M-Med	Low	Low	Deferred cost-high
Non-preferred format with complete metadata set	Low if accepted as is Med if migrate on submission	Low	Med	Low	M=Med	Low if migrated on submission Med if migrated at this stage	M=Med	Deferred cost-high
Non-preferred format with incomplete metadata set	Med if no migration High if migration	Low	Med	Low	M=Med	Low if migrated on submission Med if migrated at this stage	M=Med	Deferred cost-high
Rights negotation	Low-med	High	Med					

B=batch processed whereby tooles exist to identify and remove e-prints with the same format
M=manual removal

Creation
- File format and content types determined

Submission
Revision(s)
Quality assessment For all three of the above
- Resource Discovery metadata
- Technical metadata
- Rights metadata
- File format conversion
- Unique, persistent identifier
- Version control

End of frequent reading
Technical obsolescence
- Migration
- Emulation
- Other preservation action

Withdrawal of e-print

Selection
Negotiation
Technical strategy for preservation and access
Validation
Metadata
Storage

Yet another one (chapter 9.4):

Submission and revision

Publication
Retention assessment
Technological obsolescence
Rights negotiation (at submission and on publication)

42.)
Lavoie (2003)

Roles:
- Rights holder
- Archive
- Beneficiary

Organisational models:
- Centripetal model (Rights holder, Archive and Beneficiary are the same entity)
- Centrifugal model (Rights holder, Archive and Beneficiary are all separate entities)
- Supply-side model (Rights holder and Archive are the same entity; Beneficiary is separate)
- Demand-side model (Rights holder and Beneficiary are the same entity; Archive is separate)
- Consolidated model (Archive and Beneficiary are the same entity; Rights holder is separate)

Models for funding the archive:
- Up-front payment (users pay for a defined quantum of storage and with that one-time payment comes eternity of preservation)
- Ongoing archival fees (an “insurance premium” that gives an ongoing supply of money, adjustable as costs change and modest at all times)
- Traditional library model (Library picks up the tab and is funded by 3rd party sources)
- Fee for services operation (the archive provides certain services (e.g. special metadata) in return for payments
- Hybrid (i.e. mixture of any of the above)

Incentives to preserve 2 facets:
- Incentive to preserve (1): perceived motivation sufficient to induce a party to recognize a need to take action to secure the long-term viability of digital materials in which they are a stakeholder
- Incentive to preserve (2): perceived motivation sufficient to induce a party to develop and implement technologies aimed at ensuring the long-term viability of digital materials

43.)
Puglia (1999) provides a breakdown of costs over the stages in the creation and management of a number of digital imaging projects: selection, preparation, metadata creation, preservation/conservation of the physical object, production of intermediates, digitization, quality control of images and metadata, technical infrastructure, on-going maintenance.