Roles and Responsibilities in Digital Preservation Decision Making

Towards Effective Governance

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Abstract

In this article, we take a critical look at the current state of the art in decision making for digital preservation operations. The goal of preservation planning is to ensure that the optimal decision is taken to maintain the authenticity and understandability of digital objects. To accomplish this, the preservation planner needs to have an understanding of both the organizational context and the challenges posed by the quest for digital longevity. Clear roles and responsibilities for each process are a key success factor of effective governance. Hence, we elaborate on required activities and discuss roles and responsibilities. The conclusions shall contribute to a clarification of the planner role and highlight crucial skills and expertise required.

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1. Introduction

Decisions are required on a variety of levels in any organization concerned with a long-term view on the value of digital information, ranging from decisions about long-term strategies and the scope of preservation to the tactical level of preservation operations. This article takes a critical look at the current state of the art in decision making and governance processes for operational digital preservation. At the core of digital preservation is the question of information preservation. It focuses on the search for the

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optimal way to achieve longevity of information for a certain target group. The constant changes in technologies, user communities, and organizational context require active involvement to achieve this. In this light, a *preservation action* is a concrete action, usually implemented by a software tool, performed on specific content in order to achieve preservation goals. For instance, a preservation action can consist of the migration of content to a different format using a certain tool in a certain configuration and software and hardware environment. Operational preservation thus searches for the optimal preservation action that ensures the authenticity and understandability of specific digital content for certain users.

Frequently, preservation decisions are now taken by (small) teams of people specifically tasked with digital preservation, which is considered as a highly specialized, focused competence. However, these decisions concern very different aspects of preservation, ranging from high-level considerations about regulatory compliance and business strategies to low-level IT concerns about Quality Assurance of metadata transformations.

Governance "refers to the way the organization goes about ensuring that strategies are set, monitored, and achieved."[1] As such, governance sets the institutional and policy framework in an organization. Governance frameworks in Information Systems show that understanding the roles and responsibilities for each process is a key success factor of effective governance.[2] In this light, we outline typical chains of decisions in a preservation environment and illustrate corresponding tasks and roles in the primary dimensions of business/technology versus strategy/operations. It becomes clear that a transparent and explicit assignment of roles and responsibilities as well as a definition of expected skills and expertise for these tasks and activities is required. This applies in particular to the *preservation planner*. Given the current state of the domain of digital preservation, it is not surprising that a full understanding of the planning role has yet to be formed. However, it is clear that a successful preservation planner needs to have an understanding of the business context and goals and acquire in-depth knowledge of the technical intricacies to be resolved.

The article is structured as follows. We will shortly outline the context of digital preservation and preservation planning and clarify the scope of planning. We review experiences in a preservation planning case study in the light of the stakeholders involved, and discuss the various facets that arise in a standard preservation planning activity. We show that preservation planning needs to be positioned on an operational level, with clear goals, constraints and responsibility assignments as a prerequisite to success. We outline the tasks and activities that form part of the process, discuss the expertise and skills required for each of these, and reflect on the role of the preservation planner. We further draw conclusions about gaps that should be addressed and modeled more explicitly to support organizations in specifying their digital preservation governance processes. These conclusions shall contribute to a clarification of the state of the art and practice in digital preservation decisions and support prospective adopters of systematic preservation planning in analysing their readiness for transparent governance processes.

[1] Kenneth G. Rau, "Effective Governance of IT: Design objectives, roles, and relationships," *Information Systems Management* 21, no. 4 (2004): 35-42.
[2] IT Governance Institute, "COBIT 5 – A business Framework for the Governance and Management of Enterprise IT," 2012.

2. Digital preservation and preservation planning

Management of the diverse risks to the longevity of digital information requires awareness and treatment of threats and vulnerabilities on three different levels, the physical, logical and semantic level. On the physical level, the raw bit streams have to be preserved over time. Additionally, a correct way to interpret this bit-stream must be preserved as well, which arguably is the more challenging part of digital preservation: Digital objects require specific program versions to open and render them; these in turn depend on specific software components and an operating system, which in turn runs on and supports a specific type of hardware components. A consumer of content in turn will access objects using a specific environment that needs to support the object at hand. If any of the elements in the performance chain is lost, a digital object cannot be rendered successfully and is reduced to a useless concatenation of zeros and ones. It becomes clear that even having a storage medium being capable of retaining digital data for a millennium is worthless if the means of interpretations are lost. A comprehensive overview of the challenges in digital preservation and of preservation strategies is provided in the accompanying document to the UNESCO charter for the preservation of digital heritage.[3]

Digital curation as "*[t]he active involvement of information professionals in the management, including the preservation, of digital data for future use,*"[4] covers the entire lifecycle of a digital object from the early stages of conceiving and planning it to either its disposal or long-term preservation and possible re-use. Preservation is thus one in the entire set of curation activities.[5]

The Reference Model for an Open Archival Information System (OAIS)[6] describes, on a high level, the functional and information model of an archival information system and the exchange of information between the different entities. Furthermore it lists roles involved and their responsibilities; the three main roles described in the OAIS are *Producer, Consumer,* and *Management*. While Producers constitute "*persons or client systems that provide the information to be preserved,*"[7] the Consumers' main concern as "*persons, or client systems who interact with OAIS services*" is to "*find preserved information of interest and to access that information in detail.*"[8] *Management* is "*[t]he role played by those who set overall OAIS policy as one component in a broader policy domain.*"[9]

A core function in the model is Preservation Planning, which

> ...provides the services and functions for monitoring the environment of the OAIS, providing recommendations and preservation plans to ensure that the information stored

[3] Colin Webb, "Guidelines for the Preservation of Digital Heritage," prepared by the National Library of Australia for the Information Society Division, UNESCO, March 2003, http://unesdoc.unesco.org/images/0013/001300/130071e.pdf.
[4] Elizabeth Yakel, "Digital curation," *OCLC Systems & Services: International digital library perspectives* 23, no. 4 (2007): 335-340.
[5] Philip Lord and Alison Macdonald, "e-Science Curation Report: Data curation for e-Science in the UK: an audit to establish requirements for future curation and provision," prepared for The JISC Committee for the Support of Research (JCSR), 2003, http://www.jisc.ac.uk/uploaded_documents/e-ScienceReportFinal.pdf.
[6] International Standards Organization, *ISO 14721:2012—Reference model for an open archival information system (OAIS)*, The Consultative Committee for Space Data Systems, Recommended Practice, CCSDS 650.0-M-2, June 2012, http://public.ccsds.org/publications/archive/650x0m2.pdf.
[7] Ibid., p. 1-14.
[8] Ibid., p. 1-10.
[9] Ibid., p. 1-13.

> in the OAIS remains accessible to, and understandable by, the Designated Community over the long term, even if the original computing environment becomes obsolete.[10]

A preservation plan then

> ...defines a series of preservation actions to be taken by a responsible institution due to an identified risk for a given set of digital objects or records (called collection). The Preservation Plan takes into account the preservation policies, legal obligations, organizational and technical constraints, user requirements and preservation goals and describes the preservation context, the evaluated preservation strategies and the resulting decision for one strategy, including the reasoning for the decision. It also specifies a series of steps or actions (called preservation action plan) along with responsibilities and rules and conditions for execution on the collection. Provided that the actions and their deployment as well as the technical environment allow it, this action plan is an executable workflow definition.[11]

This preservation planning can be supported by tools such as the planning tool Plato,[12] which implements the planning method described in Becker et al. 2009.[13] The publicly available tool guides decision makers via a structured workflow to create an actionable preservation plan for a well-defined set of objects which are considered being at risk, based on a thorough goal-oriented and evidence-based evaluation of potential actions. The workflow comprises the following phases:

1. *Define requirements:* In the first phase, goals and criteria are specified that the optimal preservation action needs to fulfill. The specification starts with high-level goals and breaks them down into quantifiable criteria, thus creating an objective tree. The objective tree forms the basis for evaluating the preservation actions.
2. *Evaluate alternatives:* Empirical evidence for evaluation of all potential candidate solutions is gathered via controlled experimentation. All alternative candidates are applied to real sample content selected from the set of objects to be preserved and evaluated according to the specified set of criteria (i.e., for every criterion, a measure is collected for each experiment).
3. *Analyse results:* To allow comparison across different criteria and their measurements, a utility function is defined for each criterion. This utility function maps all measures onto a uniform utility scale. Relative importance factors on each level of the goal hierarchy model the preferences of the stakeholders. An in-depth analysis of the resulting performance of candidates (i.e., their weighted utilities throughout the goal hierarchy) leads to an informed recommendation of an alternative.
4. *Build preservation plan:* In this phase, concrete steps required to put the action plan into operation are defined. This not only includes an accurate and understandable description of on which preservation action is to be executed on which digital objects the and how, but also the

[10] Ibid., p. 4-2.
[11] Christoph Becker, Hannes Kulovits, Mark Guttenbrunner, Stephan Strodl, and Andreas Rauber, "Systematic planning for digital preservation: Evaluating potential strategies and building preservation plans," *International Journal of Digital Libraries* 1, no. 2 (2007): 92-101, http://www.ijdc.net/index.php/ijdc/article/view/27/16.
[12] http://www.ifs.tuwien.ac.at/dp/plato
[13] Becker et al., "Systematic planning for digital preservation."

quality assurance measures to be taken along with it to ensure that the results are corresponding to expectations. Furthermore, procedures and responsibilities for plan execution are defined.

As opposed to strategic planning, which is of a conceptual nature and inherently focused on a vision, the result of preservation planning is an *operational* plan with a concrete, focused preservation action fulfilling clear objectives. These objectives are focused on the overarching goal of ensuring authentic access to specific content in understandable form for a specified user group. While an organization will typically define one strategic plan, it will very often hold more than one homogeneous set of objects of interest for more than one group of users. This means that a set of preservation plans will be required to specify concrete actions to take for keeping the sets of digital objects alive over time according to the organization's strategy and policies, and these plans will evolve according to different lifecycles than the strategic plans. This distinction is crucial to ensure proper alignment of preservation planning to the strategies and policies of the organization.

Preservation policies in turn have been discussed on different levels. Criteria such as the ISO 16363 Repository Audit and Certification Criteria[14] aim for verifying the compliance of an archive to what are perceived as standard "best practices". On an operational level, executable rules such as those described in MacKenzie and Reagan, 2007[15] aim at operational control of preservation systems and support monitoring the compliance of a system to specified constraints. For decision making, however, policies are non-enforceable elements of governance that guide, shape and control the strategies and tactics of an organization.[16] This is also the perspective we adopt in this article where we speak about policies.

3. Preservation planning in practice

The Bavarian State Library (BSB) has been amongst the first institutions to actively deploy the planning process discussed above in an organization. Triggered by the observation that institutions such as the British Library decided to move forward towards migrating parts of their collections to JPEG2000, the BSB questioned the current file format of choice for high-quality scans, which constitute one of their largest digital collections.

Staff from the library embarked on a quest to find the optimal file format for this particular type of content and prepare a preservation plan.[17] Storing image files without using compression makes them more robust against bit corruption. However, going without compression has to be balanced against incurring storage costs. The state library thus commenced planning with the specific goal to evaluate the option of migrating to JPEG2000, i.e., evaluating whether the BSB would benefit from migrating their TIFF collections to JPEG2000.

[14] International Standards Organization, *ISO 16363:2012—Space data and information transfer systems -- Audit and certification of trustworthy digital repositories*, The Consultative Committee for Space Data Systems, Recommended Practice, CCSDS 652.0-M-1, September 2011, http://public.ccsds.org/publications/archive/652x0m1.pdf.

[15] MacKenzie Smith and Reagan W. Moore, "Digital Archive Policies and Trusted Digital Repositories," *International Journal of Digital Curation* 1, no. 2 (2007): 92-101, http://www.ijdc.net/index.php/ijdc/article/view/27/16.

[16] Object Management Group, "Business Motivation Model 1.1," 2010.

[17] Hannes Kulovits, Andreas Rauber, Markus Brantl, Tobias Beinert, and Anna Kugler, "From TIFF to JPEG2000? Preservation planning at the Bavarian State Library using a collection of digitized 16th century printings," *D-Lib Magazine* 15, no. 11/12 (November/December 2009), http://dlib.org/dlib/november09/kulovits/11kulovits.html.

A series of different people were involved in the preservation planning process. While two people from the library staff were in charge of proceeding through the steps of the planning workflow in general, the process of gathering the preservation goals and criteria involved a number of people from within the organization and outside. The people involved in key planning tasks were the following.

- The head of the digital library and digitization services was responsible for defining of the planning scope, specifying and clarifying goals and constraints, and approving the preservation plan.
- The person responsible for the digitization process and its implementation contributed knowledge on peculiarities of the digital image files, including metadata of the scanning process.
- The person responsible for storage at the supercomputing center that provides the technical storage facilities for the state library made sure that limitations of the technical infrastructure were considered. This included restrictions on possible preservation action tools and storage limitations. Furthermore, the retrieval and re-ingest process had to be considered with respect to costs and feasibility.
- Two library researchers and a historian were responsible for the identification of significant properties, a comprehensive definition of the user community, and the evaluation of the considered preservation actions.
- Finally, an external preservation planning expert moderated the workshops and guided the decision makers through the steps of preservation planning.

In the beginning, a clear **definition of the planning scenario** had to be created. This definition specifies a certain set of digital objects and the user community for whom its accessibility is of concern. In this case, the focus was on high-quality scans of 15th and 16th century incunabula, which are made accessible in a low-resolution copy to the general public via the internet. Reproductions of the original are produced using the high-resolution master file.

Once the scenario has been defined, the **context** in which the preservation plan operates needs to be documented; legal obligations/restraints, organizational workflows, and policies relevant to this plan need to be documented. In this case, certain policies of the agency funding the digitization of the incunabula had to be considered. For instance, requirements for the quality of the digital copy had to be respected.

To understand the risks facing the content and describe the scenario at hand, the organization must create a **content profile** describing technical characteristics such as file formats, format versions, date of creation, and the number of embedded objects ('Know what you have'[18]). In this case, the collection encompasses more than four million pages of high-quality scans, which were digitized in the course of a funded project between 2007 and 2009. All master files are stored as TIFF version 6 without compression to enable reproductions as close to the original as possible. The collection measures 72 Terabyte.

The search for the optimal action to take continues with specifying the **goals and objectives** that should be met. These need to be collected from a variety of stakeholders and have to be specified in a quantifiable way, starting at high-level objectives and breaking them down into measurable criteria (e.g., bits per sample, Euros per year, frames per second). The resulting objective tree forms the basis of the

[18] Thomas Bähr, Michelle Lindlar, and Sven Vlaeminck, "Puzzling over digital preservation – Identifying traditional and new skills needed for digital preservation," in *World Library and Information Congress: 77th IFLA General Conference and Assembly, San Juan, Puerto Rico, 13-18 August 2011*, http://conference.ifla.org/past/ifla77/217-bahr-en.pdf.

evaluation of potential preservation actions. In this case, two half-day requirements sessions were held at the Bavarian State Library to gather the different stakeholder's objectives.

A **set of preservation actions** potentially fulfilling the requirements, need to be selected and the experiment setting determined ('Know what comes ahead'[19]). In this case, image conversion tools such as ImageMagick and GraphicsMagick were incorporated into the evaluation.

Carrying out the **experiments** means that each preservation action needs to be applied to each sample object according to the experiment specification. In this case, sample files taken from the collection were migrated using the preservation action tools including ImageMagick. The result was then analysed using characterization tools such as JHove. Using the empirical **evidence** from conducting the experiments, the criteria on the leaf level of the objective tree were then evaluated; the criterion *image size unchanged* for instance could then be evaluated depending on the outcome to either *yes*, or *no*. In order to make the **evaluation values** comparable amongst each other, each criterion in the objective tree was then transformed to a uniform scale between 0 and 5, with 0 being unacceptable and 5 being the best possible evaluation. An essential step is taken here: **Acceptance criteria** are defined and clearly state the constraints the institution is willing to accept. Aggregation of these values over the tree hierarchy leads to a directly **comparable performance value** at root level for each preservation action, with a higher performance value indicating better overall performance. The interested reader is referred to Becker et al., 2009[20] for detailed information on the aggregation methods. The entire evidence aggregated to a comparable performance value for each alternative action enables a well-documented and **informed decision** for the preservation action scoring highest performance value.

Evaluation of the potential preservation actions against these objectives resulted in the recommendation to keep the files in their original configuration (TIFF 6, without compression). While this decision kept the status quo, it was the result of an informed and accountable decision-making process specified in a **standardized preservation plan**. The benefits of conversion were at this point outweighed by the costs and risks. The decision was scheduled for review at a later point in time to make sure that potential changes in decision factors will be considered.

All the activities described above had to be carried out by the respective responsible person and documented accordingly. Since the creation of this preservation plan was the organization's first structured approach to finding the optimal solution for a preservation problem, top management had to be called in for certain decisions in some cases. In particular, the organization's policies and strategies had not been fully formed yet at that time. Hence, this first planning activity also laid the ground for subsequent planning efforts for other collections.

The key questions that arise during planning are summarized in Table 1, together with the problem areas they touch upon. The person responsible for planning needs to have an understanding of these areas to be capable of leading the process.

The first phase focuses on a deep understanding of the current situation, i.e., the organizational context, the content and its properties, formats and associated risks, as well as the goals and objectives to be achieved. This is in many ways the crucial phase for planning, and requires the decision makers to understand how they can make their high-level goals and objectives operational to enable informed decisions. For instance, for the Austrian State Archive, the preservation of pre-written official speeches created by the Federal President or his/her employees are of particular historical interest. Such documents

[19] Ibid.
[20] Becker et al., "Systematic planning for digital preservation."

Table 1. Key questions and problem areas touched.

Phase	Key questions	Problem areas touched
1: Define requirements	• For which digital objects do we create a preservation plan, and why? • Which samples of the objects are representative of the set? • Which are the significant properties of these objects? Who will want to use them, and what are their access requirements?	• Risks to the longevity of digital information • Institutional and Organizational Contexts • User communities • Content profiling and automated analysis • Authenticity • Significant properties • Requirements analysis
2: Evaluate alternatives	• Which preservation actions could we apply to keep this content alive and understandable? • What are the effects of applying a certain preservation action? • How can we evaluate software components? • How can we ensure trustworthy decisions?	• Preservation actions • Controlled experimentation • Information sources, evidence, and trustworthiness Software engineering • Significant properties
3: Analyse results	• What are our preferences? • Which are the critical requirements? • Which loss can we accept? • Which costs can we accept? • Which risks can we accept? • Can we achieve our intended goals with the available means within the constraints of our organization?	• Organizational preferences, goals and risks • Multi-criteria decision making • Sensitivity of decision criteria • Authenticity and acceptable loss
4: Define plan	• What are the essential steps required to execute the plan as intended? • How can we ensure successful execution of the plan corresponding to specifications? • Who should be responsible for executing the preservation? • Who should be responsible for quality assurance? How much quality assurance is required? • To which degree can we automate preservation actions and quality assurance? • How long should the plan be valid? When do we have to review it? • Which key factors do we need to monitor from now on to ensure we react to critical changes?	• Functional correctness of software tools used for quality assurance • Roles and responsibilities • Service quality • IT operations • Continuous monitoring

often tell a story themselves; they have gone through many iterations until the final version, and are provided with annotations concerning the exact flow of the speech. These documents are commonly stored in the version of Microsoft Word format that was prevalent at the time of creation. Incompatibilities between text editors and their versions make a migration of these documents necessary. This, however, needs to be accurately planned to make sure that the requirements of the different users of these documents are addressed. A high-level goal of the responsible archivist for instance states that

"*Documents created by the Federal President or his/her staff about official speeches need to be preserved as they are (including edit history, comments, and remarks regarding intonation).*" This requires further breakdown into measurable criteria such as: (1) *Change history must be retained.* (2) *Comments including full name of person and date/time of creation must be preserved.* (3) *Text colour must be retained*.

The second phase requires more technical expertise in conducting experiments that evaluate the feasibility and quality of potential alternatives. In the third phase, on the other hand, the focus lies on organizational preferences, assessment of costs, benefits and risks, and acceptable loss. Finally, the fourth phase requires specification of technical processes and quality management, as well as an understanding of roles and responsibilities in the organization.

Finally, preservation planning is not an isolated procedure. It needs to be accompanied by continuous monitoring of all factors (internal as well as external to the organization) that influenced the planning result. Once a preservation plan has been created and put into operation, quality of service, shifts in designated user communities and their requirements, and the technology environment need to be monitored. Changes should result either in the revision of an existing plan or the creation of a new plan.

4. Preservation planning in context

Preparation of a plan often touches several departments in the organization and thus needs cross-departmental coordination and communication. The desired outcome is the mitigation of an identified risk for a given set of digital objects. The plan provides clear information concerning resource requirements and staffing, quality standards, deployment of the action must comply with, and the schedule of the implementation of the plan.

Many of the decision steps in planning require contextual information. For example, the desirable properties of formats risks and features are generally uniform across an organization, and in fact very similar across organizations. These preferences and the organization's corresponding risk aversion thresholds need to be supplied to the planning procedure. Such information may be documented in policies addressing external constraints as well as in policies addressing internal goals and directives that control decisions and operations.

This observation highlights the necessity to embed operations and planning in a strong and well-understood organizational context, and align planning to strategic objectives and policies. The perspective hereby needs to be based on a socio-technical system view of a preservation environment, addressing the question "Which capabilities does an organization need for successful preservation"? A capability hereby is an "*ability that an organization, person, or system possesses. Capabilities are typically expressed in general and high-level terms and typically require a combination of organization, people, processes, and technology.*"[21]

The SHAMAN reference architecture for Digital Preservation[22] correspondingly provides a contextualized capability-based view on digital preservation, with a strong foundation in Information Systems and Enterprise Architecture frameworks, and thus a more holistic and socio-technical view on the field of digital preservation. It describes goals, drivers and constraints, typical key stakeholders and their concerns, and key capabilities which an organization needs to possess to fulfill its digital preservation mandate. It thus can serve as a guide to understanding governance processes, roles and

[21] http://pubs.opengroup.org/architecture/togaf9-doc/arch/chap03.html#tag_03_26 (accessed 31 August 2012).
[22] SHAMAN Reference Architecture v3.0, "Project Deliverable," 2012.

responsibilities. Figure 1 shows the relationship between the top-level capabilities, which are grouped in Governance, Business, and Support capabilities. Detailed discussions can be found in SHAMAN, 2012[23] and Becker et al., 2011.[24]

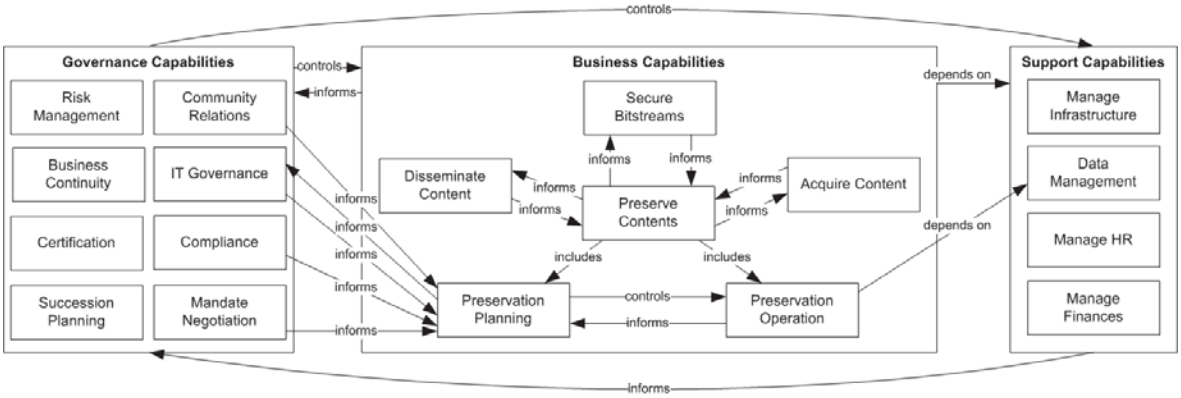

Figure 1. Relationships of digital preservation capabilities.[25]

Not surprisingly, at the heart of the capability model is the capability **Preserve Contents**, which is the "ability to maintain content authentic and understandable to the defined user community over time and assure its provenance."[26] It is composed of Preservation Operation and Preservation Planning.

Preservation Operation is the "ability to control the deployment and execution of preservation plans. This includes analysing content, executing preservation actions and ensuring adequate levels of provenance, handling preservation metadata, conducting quality assurance, and providing reports and statistics, all according to preservation plans."[27]

Preservation Planning is the "ability to monitor, steer and control the preservation operation of content so that the goals of accessibility, authenticity, usability and understandability are met while minimizing operational costs and maximizing (expected) content value. This includes managing obsolescence threats at the logical level as the core risk affecting content's authenticity, usability and understandability."[28] As emphasized above, preservation planning requires contextual information about the preservation drivers, goals and constraints. This information is managed by a set of **governance capabilities**. As a whole, the governance capabilities manage the scope, context and compliance of the system in order to ensure the fulfillment of the mandate and sustainable operation of the system.

Each of these capabilities must be realized by a combination of organization, people, processes, and technology. For example, the planning tool Plato provides systematic tool support for planning. However, the question remains how the corresponding capability can be specified, created, and assessed in a real

[23] Ibid.
[24] Christoph Becker, Gonçalo Antunes, José Barateiro, and Ricardo Vieira, "A Capability Model for Digital Preservation: Analyzing Concerns, Drivers, Constraints, Capabilities and Maturities," in *Proceedings of the 8th International Conference on the Preservation of Digital Objects (iPRES2011), Singapore, November 1-4, 2011* (Singapore: National Library Board and Nanyang Technological University, 2011), 1-10.
[25] Ibid.
[26] Ibid.
[27] Ibid.
[28] Ibid.

organization. This realization of the planning capability requires the development of an organizational process that assigns responsibilities to roles and models the activities and tasks that have to be performed. To better understand the roles and responsibilities that have to be considered, the next section elaborates on the involved stakeholders and roles and discusses the relationship of these roles in a real-world organizational scenario.

5. Stakeholders and roles within the preservation context

In any organization running a digital repository to long-term preserve digital information, a number of stakeholders will be involved in preservation activities. This section thus discusses typical stakeholders and their roles and responsibilities in preservation processes. Table 2 provides an idealized categorization of typical stakeholder profiles, based on the SHAMAN reference model, and illustrates each role with the key responsibilities. The exact roles and responsibilities will certainly vary on an organization basis and have to be correspondingly adapted to each specific organizational context. Moreover, additional roles such as technical operators, technology providers and external regulators are not covered here. However, these idealized profiles serve as a guideline for the discussion of responsibilities, expertise and skills. This will provide the background of discussing the role of the *preservation planner*.

Table 2. Roles and their responsibilities.

Title	Role
Executive Manager	This role is responsible for setting the overall goals and objectives of the organization, ensuring that the mandate is fulfilled and the repository continues to serve its designated community. The Executive Manager defines the strategic goals to be achieved and may need to resolve conflicts arising between ends and means.
Responsibilities	
• Negotiation and fulfillment of mandate • Assignment of roles and responsibilities in the organization • Strategic planning • Succession planning • Conflict resolution • Organizational and financial management • Financial sustainability • Certification management • Legal compliance	
Title	**Role**
Repository Manager	This role is responsible for ensuring repository business continuity, defining business strategies in line with strategic goals, and setting goals and objectives to be achieved by operational management. The Repository Manager operates on the business domain, which requires interaction with the designated communities including producers/depositors and consumers, and the legal environment.
Responsibilities	
• Relationship to user communities (producers and consumers) • Relationship to the organizational and legal environment • Awareness of the preservation context • Operational goals and fulfillment • Compliance of business operations with strategic goals	

• Specification of organizational preferences, goals and risks • Authenticity and acceptable loss	
Title	**Role**
Technology Manager	The person responsible for technological system continuity and the deployment of technological means to achieve the ends set by the repository business. This role effectively acts as a regulator to the operational manager due to the fact that the choice of technology limits the operational application of means to achieve ends.
Responsibilities	
• Technical infrastructure management • IT infrastructure change management • Fulfillment of service level agreements • Operations and reporting • Acquisition of adequate platforms and components	
Title	**Role**
Operational Manager	The person responsible for continuous policy-compliant operation of the repository, which involves balancing ends and means and resolving conflicts between them, i.e., constraints as set from Technology Management and Preservation Management. Besides balancing means and ends through decision making, the operational manager is also responsible for overseeing operations and exerting control over operational staff.
Responsibilities	
• Content profiling and analysis • Authenticity of content • Operational decision-making to balance ends and means • Making drivers and goals operational • Cost-benefit analysis • Definition of preservation plans • Monitoring of relevant influence factors • Monitoring of the efficient deployment of resources • Compliance monitoring of operations • Controlled experimentation	
Title	**Role**
Operator	The person responsible for the operation of the repository and is aware of the details of the design and deployment of the system.
Responsibilities	
• Repository operations and monitoring • Preservation operations and monitoring • Execution of experiments • Systems configuration and IT operations • Database management and support • Technical documentation • Reporting	

From these typical responsibilities, we can see that the role that is responsible for preservation planning is what above is called the *Operational Manager*. However, it is evident that the different roles do not operate independently from each other, but interact on many different levels offering several areas of

friction. Figure 2 (derived from Becker and Rauber, 2011[29]) shows typical stakeholders and their key relationships within the dimensions *strategic/tactic* and *business/technology* on the left side. It illustrates the problem space and its continuum from technological means to business ends. On the right side, it illustrates the exemplary assignment of these same roles as it is found in the Digital Archive of Austria. It is interesting to note that in this case, three of the management roles are in fact assigned to boards, not single persons. We omit additional related roles and activities such as technology providers and further technical staff.

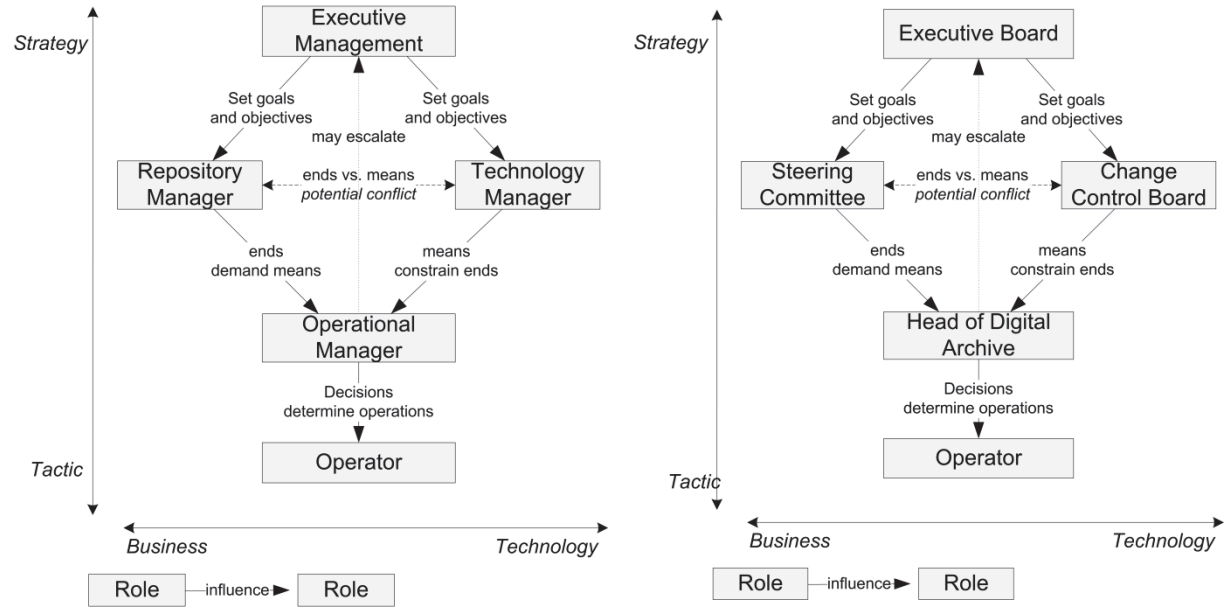

Figure 2. Decision making roles: Idealized stakeholders (left) and exemplary assignment (right).

6. Preservation tasks and required skills and knowledge

Clearly, the actors in a preservation context require a broad set of skills and expertise if they are to preserve digital objects into perpetuity. An understanding of the business goals the organization strives to achieve, the environment it is operating in and the processes it has implemented are just as important as an in-depth knowledge of the technical challenges digital objects pose.

To clarify which specific skills and expertise should be acquired, we build upon the considerable amount of work dedicated to identifying required skills and knowledge for digital curators. The DigCCurr[30] project aimed at building a digital curation curriculum. Bähr, Lindlar, and Vlaeminck, 2011[31] describe necessary know-how and prevalent gaps with a focus on libraries. Engelhardt, Strathmann, &

[29] Christoph Becker and Andreas Rauber, "Preservation Decisions: Terms and Conditions apply. Challenges, Misperceptions and Lessons Learned in Preservation Planning," in *Proceedings of the ACM/IEEE Joint Conference on Digital Libraries (JCDL'11), Ottawa, Ontario, Canada, June 13-17, 2011* (New York, NY: ACM, 2011), 67-76.
[30] http://ils.unc.edu/digccurr (accessed 31 August 2012)
[31] Bähr et al., "Puzzling over digital preservation."

McCadden[32] report on an international survey on training needs in digital curation and preservation conducted in the DigCurV[33] project.

In the DigCCurr project, a matrix of knowledge and skills necessary for carrying out digital curation work has been developed.[34] The authors describe the scope of digital curation and elaborate categories of required knowledge and skills. The matrix identifies and organizes the material that shall be covered in a digital curation curriculum. It is organized along six dimensions: *mandates, value, and principles* (institutional/context specific reasons why the curation functions are carried out and how to evaluate them); *functions and skills* (explicit knowledge of curation methods); *professional, disciplinary, institutional, organizational, or cultural context* (institutional/context specific peculiarities); *type of resource* (as the target of the curation work); *instrumental knowledge* (prerequisite knowledge such as characteristics of technologies); and *transition points in the information continuum* (understanding points of digital content transition from pre-creation to secondary use environments). Each dimension contains categories of knowledge and skills that the authors consider necessary for digital curation work and shall thus be taught to students.

Building upon this, we can position core tasks of preservation planning and analyse the required skills and knowledge. In the following, we list activities necessary for preservation planning and preservation operation and assign to them the categories, as specific areas of skills and knowledge. We add skills and knowledge categories (in **bold**) which we consider important but do not see covered by a category mentioned in Lee and Tibbo, 2011.[35] Table 3 gives a description of these additional skills and knowledge categories, The focus hereby is on domain-specific skills that are required by the problem area itself, not on (certainly relevant) management skills such as conflict resolution and coordination. While some of these categories are related to broader categories in Lee and Tibbo, 2011,[36] they refer to particular aspects of more specific relevance to preservation than those discussed there. Similarly to the DigCCurr skills matrix, these extended categories are not meant to be exhaustive, but should be understood as identified key areas of expertise that are seen as essential.

Table 4 and Table 5 provide the categories of tasks and skills for preservation planning and preservation operations.

In addition to the core tasks of preservation planning and operations, a number of context-related activities are located in the governance capabilities. These include tasks for managing the preservation context, as shown in Table 6.

As we see from the activities, skills, and expertise areas necessary to successfully plan for digital information longevity, the preservation planner as the person responsible for taking preservation measures needs to have an understanding of both the business goals that need to be achieved and the technical risks that need to be mitigated along that way.

Many decisions taken within the scope of preservation planning are based on contextual information and need to be communicated through appropriate policies. These policies are often related to

[32] Claudia Engelhardt, Stefan Strathmann, and Katie McCadden, "Report and analysis of the survey of Training Needs," *DigCurV - Digital Curator Vocational Education Europe Project*, 2011, http://www.digcur-education.org/eng/Resources/Report-and-analysis-on-the-training-needs-survey.
[33] http://www.digcur-education.org/
[34] Christopher A. Lee and Helen Tibbo, "Where's the Archivist in Digital Curation? Exploring the Possibilities through a Matrix of Knowledge and Skills," *Archivaria* 72 (Fall 2011): 123-168.
[35] Ibid.
[36] Ibid.

Table 3. Knowledge and skills.

Knowledge and skills category	Explanation
Content Analysis	Understanding of the characteristics of digital content, digital encodings and formats. This includes format risks, content corruption, interoperability between environments, dependencies, format identification methods and tools as well as scalable analysis of large content collections.
Requirements Analysis	Knowledge and identification of the criteria categories relevant for the planning scenario. Identification and bringing together of relevant stakeholders around a table to gather requirements. Guidance of requirements elicitation workshops with a focus on steering participants towards an accurate problem description rather than anticipating solutions.
Preservation Actions	Understanding and appreciation of the range of potential preservation actions including a differentiation according to type. No preservation action type (such as migration) should be given priority to another (such as emulation) without knowing their strengths and weaknesses in a certain application domain.
Preservation Action Quality Assurance	Development and implementation of quality assurance workflows especially with respect to automation. Understanding possible weaknesses of software programs. Measurement and correct interpretation of criteria necessary to assure a digital object's quality.
Information Sources, Evidence, and Trustworthiness	Understanding of the role of evidence for trustworthiness. Knowledge of the kinds of sources of information that can provide indicators and evidence for decisions. Knowing knowledge bases from where measurements to certain properties can be obtained from and assessing their trustworthiness.
Controlled Experimentation and measurement	Knowledge of how properties of digital objects, formats, software, software executions can be measured. Appreciating the importance of the usage of relative measures instead of absolute to facilitate comparison. Understanding of experiment design, execution and documentation of evidence. Recognizing the importance of replicability and repeatability of experiment results in the long term as an essential part of evidence-based decision making.
IT Operations, Quality, and Management	Understanding of the basic acquisition, development, evaluation, configuration, operation, maintenance, and change management processes required to successfully operate IT systems. This includes an understanding of the concept of software quality as defined for example in ISO 25010 'Systems and software engineering - Systems and software Quality Requirements and Evaluation (SQuaRE) - System and software quality models' (International Standards Organization 2011)
Decision making with multiple criteria	Understanding of approaches to quantify and compare multiple criteria and take accountable decisions in a systematic way. This includes trade-offs between conflicting objectives, and the ability to make goals and constraints (such as costs and benefits) operational
Risk Management	Understanding of the nature of uncertainty and risk management and its relevance in the preservation context. This includes concepts such as uncertainty, probability, likelihood, impact, mitigation, opportunities, risk assessment methods, and continuous risk monitoring.

the regulatory environment or to compliance criteria such as those contained in the ISO 16363 Repository Audit and Certification catalogue (International Standards Organization 2012). Preservation planners have to be able to assess their organizational implications and understand how and where they enter the

Table 4. Required skills and knowledge for preservation planning tasks.

Core tasks of preservation planning	Required skills and knowledge
Make drivers and goals operational, i.e., define objectives and constraints represented by decision criteria.	Significant Properties; **Controlled Experimentation and measurement;** Analysis and Characterization of Digital Objects/Packages; Automation; **IT Operations, Quality, and Management; Requirements Analysis; Preservation Actions; Preservation Action Quality Assurance; Information Sources, Evidence, and Trustworthiness; Decision making with multiple criteria**
Select a (minimal) set of relevant preservation actions for assessment which potentially fulfil the defined requirements.	Automation; Archival Storage; Common Services; Scale and Scalability; Purchasing and Managing Licenses to Resources; Transformation of Digital Objects/Packages; **Preservation Actions**
Assess preservation actions against the specified requirements.	Automation; Analysis and Characterization of Digital Objects/Packages; **Information Sources; Evidence, and Trustworthiness; Controlled Experimentation and measurement**
Specify actions and directives in an understandable form and deliver it to the unit responsible for deployment.	Automation; Archival Storage; Common Services; **Preservation Action Quality Assurance**

Table 5. Required skills and knowledge for preservation operation tasks.

Core Tasks of Preservation Operation	Required skills and knowledge
Execution of preservation actions according to preservation plans and ensure full documentation of the execution process.	Evidence; Provenance; Scale and Scalability; Robustness; Description, Organization, and Intellectual Control; Transformation of Digital Objects/Packages; Transfer; **IT Operations, Quality, and Management**
Analysis of technical characteristics of content	Significant Properties; Provenance; Stakeholders; Analysis and Characterization of Digital Objects/Packages; Characteristics of Information and Record Creating Environments; Level of Aggregation; Characteristics of Technologies; **Content Analysis; Risk Management; IT Operations, Quality, and Management; Preservation Actions; Controlled Experimentation and measurement**
Control the processing of appropriate preservation metadata corresponding to chosen standards.	Evidence; Provenance; Description, Organization, and Intellectual Control; **IT Operations, Quality, and Management**
Measure properties of renderings/performances and compare them to each other to measure their equivalence corresponding to requirements.	Significant Properties; Description, Organization, and Intellectual Control; Validation and Quality Control of Digital Objects/Packages; **Preservation Action Quality Assurance; IT Operations, Quality, and Management**
Produce documentation of activities in an adequate and understandable form.	Evidence; Provenance; Description, Organization, and Intellectual Control; **IT Operations, Quality, and Management**

Table 6. Required skills and knowledge for managing preservation context.

Core Tasks of Managing the Preservation Context	Required skills and knowledge
Collect and describe all relevant influence factors that facilitate or restrict the decision for a preservation action; i.e., all drivers, constraints and goals applicable. Examples for external influencers include user communities, access requirements or regulations.[37]	Accountability; Authenticity; Chain of custody; Context; Provenance; Significant properties; Stakeholders; Standardization; Sustainability; Trust; Transformation of Digital Objects/Packages; Professional Contexts; Disciplinary Contexts; Institutional or Organizational Contexts; Characteristics of Information and Record Creating Environments; Format; **Requirements Analysis; Information Sources, Evidence, and Trustworthiness**
Define the potential communities of users to the organization's holdings and document their requirements and available access means.	Context; Stakeholders, Sustainability; Trust; Collaboration, Coordination, and Contracting with External Actors; Professional Contexts; Disciplinary Contexts; Institutional or Organizational Contexts; Characteristics of Information and Record Creating Environments
Monitor internal and external influence factors of relevance.	Long Term, Open Architecture, Stakeholders, Analysis and Characterization of Digital Objects/Packages; Professional Contexts; Disciplinary Contexts; **Preservation Actions; Risk Management; IT Operations, Quality, and Management**
Analyse and document preservation and access requirements in the organization's communities.	Stakeholders; Significant Properties; Context; Sustainability; Trust; Collaboration, Coordination, and Contracting with External Actors; Institutional or Organizational Contexts; Characteristics of Information and Record Creating Environments; **Requirements Analysis**

planning process. It is the preservation planner's duty to be aware of and understand the organization's policies and ultimately adhere to them in planning so that the specified operations are policy-compliant. However, current methods and tools provide only incomplete specifications and means to support this coordination between context-awareness, guidance and strategies, and operational decision making.

The preservation planner must have detailed knowledge of digital objects relevant to the organization, be it ordinary files or database records, and their rendering through the characteristics that must be preserved to maintain its authenticity and understandability. Preservation actions which appear as software tools depend on computer hardware, operating systems and software libraries and need to be understood with regard to their long-term suitability. Finally, the preservation planner also needs to provide crucial input to the mandate negotiation process, since it is the planner's responsibility to answer the question whether a particular digital object's authenticity and understandability can be preserved with the available means.

A recent study of training needs in digital preservation revealed that respondents indicate 'Preservation & data management planning' and 'Preservation tools' amongst the areas where they are lacking the required knowledge and skills the most.[38] This may also come from the yet little-understood planner role including its knowledge and skills required to be capable of preserving the complex

[37] A comprehensive list of internal and external drivers is given in SHAMAN 2012.
[38] Engelhardt et al., "Report and analysis of the survey of Training Needs."

dependency network of file formats, software, operating systems, and hardware. Irrespective of the actual profession of the person planning for preservation – be it an archivist, librarian or digital curator – we showed that solid IT knowledge is prerequisite to successful preservation planning. This needs to be combined with skills in organizational understanding, as for instance imparted in business informatics studies. Well-established standards and methods from Information Systems and Software Technology need to be followed in the operational planning of preservation measures.

Conclusions and Outlook

In this article, we discussed the current state of the art in decision making for digital preservation planning and operations and elaborated on required activities. Effective governance requires a clear assignment of roles and responsibilities. Based on a socio-technical perspective on the capabilities required for ensuring digital information longevity, we illustrated typical roles and their responsibilities in the areas of Preservation Planning and Preservation Operations. We listed tasks required to prepare a preservation plan, and associated each task to the knowledge and skills that the responsible person should possess. We furthermore highlighted that an ideal preservation planner combines solid IT knowledge and skills with an understanding of organizational processes.

An organization that intends to develop systematic preservation planning and operations capabilities requires a well-defined governance framework and methods for diagnosing existing capabilities and defining a roadmap for capability development. Although widely accepted, catalogues of compliance criteria such as ISO 16363 do not support organizations in systematically assessing and improving their capabilities. In general, the wide body of digital preservation reference models and frameworks provide a common language, building blocks, and other types of knowledge derived from an in-depth analysis of the domain. However, these models are not always well-founded and consistent. Systematic approaches for governance can be adopted from fields of Information Systems and IT Management.[39]

While this article focused on preservation planning and operations, it is clear that managing the preservation context requires a similarly systematic approach. On the one hand, the corresponding capabilities and governance processes need to be clearly specified. On the other hand, "preservation policies" are defined on very different levels of granularity, clarity, and ambiguity. There is a strong need for a well-defined, standard approach to representing organizational preservation goals, objectives, constraints and directives in a systematic way to ensure that the preservation context is properly documented and communicated. This is also a crucial enabler for increased automation in preservation planning and operations.

Acknowledgements

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[39] Christoph Becker, Gonçalo Antunes, José Barateiro, Ricardo Vieira, and José Borbinha, "Control Objectives for DP: Digital Preservation as an Integrated Part of IT Governance," in *Proceedings of the 74th Annual Meeting of the American Society for Information Science and Technology (ASIST 2011), New Orleans, LA, USA, October 9-13, 2011*, http://publik.tuwien.ac.at/files/PubDat_203334.pdf.

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