The NDSA Levels of Digital Preservation: Explanation and Uses

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Abstract

The "Levels of Digital Preservation" being refined now by the National Digital Stewardship Alliance (NDSA), is a tiered set of recommendations on how organizations should begin to build or enhance their digital preservation activities. A work in progress, it is intended to be a relatively easy-to-use set of guidelines useful not only for those just beginning to think about preserving their digital assets, but also for institutions planning the next steps in enhancing their existing digital preservation systems and workflows. It allows institutions to assess the level of preservation achieved for specific materials in their custody. It is not designed to assess the robustness of digital preservation programs as a whole since it does not cover such things as policies, staffing, or organizational support. The guidelines are organized into five functional areas that are at the heart of digital preservation systems: storage and geographic location, file fixity and data integrity, information security, metadata, and file formats.

This paper presents the Levels, explains the context of the project's development within the NDSA, describes the rationale behind each of the guidelines and why they were prioritized the way they were, suggests how the guidelines may be used, and compares and contrasts the Levels to other ways of assessing stages of digital preservation. Other assessment models include Nancy McGovern and Anne Kenney's "The Five Organizational Stages of Digital Preservation," Charles Dollar and Lori Ashley's "Digital Preservation Capability Maturity Model," and OCLC Research's 2012 report, "You've Got to Walk Before You Can Run: First Steps for Managing Born-Digital Content Received on Physical Media." Finally, the paper requests feedback on the work in progress and outlines planned future work.

Introduction and Background

The National Digital Stewardship Alliance (NDSA), a diverse group of over 140 organizations whose mission is to "establish, maintain, and advance the capacity to preserve our nation's digital resources for the benefit of present and future generations" [1] has recently developed the NDSA Levels of Digital Preservation. The Levels of Digital Preservation are a tiered set of guidelines and practices intended to offer clear, baseline instructions on preserving digital content at four progressive levels of sophistication across five different functional areas. The recommended activities within the Levels are agnostic towards both content type and technology, focused on specific preservation actions (as opposed to organizational requirements), and are designed to offer a practical blueprint that can be utilized by institutions of all sizes and resource levels to perform digital preservation. The primary goal of the Levels of Digital Preservation chart is to meet the need for straightforward, accessible practices that are more substantial than the conventional digital archiving advice geared towards individuals, but less daunting and demanding than those required for certification as a trustworthy digital repository. This paper describes the Levels of Digital Preservation's origins and development within the NDSA, explains its purpose and goals, reviews related digital preservation models, presents the levels, and explicates them. The paper includes suggestions for using the Levels and implementing its activities. The paper closes with future plans for encouraging further community feedback and supporting the continued evolution and refinement of the Levels.

At the core of the Levels of Digital Preservation's creation and development is the collaborative spirit that underpins the NDSA. As an alliance composed of a variety of institutions, from large research universities to small cultural heritage institutions, from non-profit organizations to commercial partners, the NDSA offers an ideal environment to develop a resource beneficial to the varied types of individuals and institutions operating or hoping to initiate digital preservation programs. The NDSA contains a multiplicity of skills, expertise, and experience in a diverse membership dedicated to the many tasks and responsibilities involved in digital stewardship. This diversity was invaluable in conceptualizing and articulating the goals and final form of the Levels of Digital Preservation. This project was also notable as being the first NDSA-wide collaboration, as it featured members drawn from all five of the NDSA's Working Groups: Content, Standards, Infrastructure, Innovation, and Outreach. The team working on this project thus reflected the diversity of the NDSA membership and it ability to work in cooperative, cross-discipline groups.

The project to define levels of digital preservation originated when a number of different NDSA members recognized the need for practical, actionable, and scalable digital preservation guidance that was accessible both to those just getting started and those with fully implemented preservation programs. In informally surveying NDSA members, as well as researching existing digital preservation models, the project team identified a number of desired goals for the Levels of Digital Preservation. The team wanted the Levels to feature actions independent of specific formats, content types, and storage systems, thus enhancing their usability across domains. The team wanted the levels of digital preservation to be comprehensive in scope, but also simple and practical as far as specific actions. The Levels should be able to inform immediate procedures to mitigate the loss of digital content, but also be broad enough to help forecast next steps in preservation and support strategic planning and internal advocacy for preservation efforts.

The project team focused on creating a matrix of activities that were detailed enough to be meaningful, while still being succinct enough to fit on a single page, a goal intended to enhance

the chart's intellectual accessibility and demystify the sometimes-bewildering array of activities involved in digital preservation. The team wanted its product to define a community-approved minimum level of prerequisites for performing digital preservation while providing recommendations for making existing programs more robust. Furthermore, the team also wanted the language of the Levels to be non-technical and free of jargon, a strategy intended to avoid alienating or confusing those who are new to digital preservation. Similarly, the Levels would take a non-judgmental approach in order to be of maximum utility to those institutions unsure of how to begin a digital preservation program. Fundamentally, the NDSA wants the Levels of Digital Preservation to be accessible and wants them to be used.

The tiered, matrix approach of the Levels of Digital Preservation features multiple levels and content areas, and is intended to allow for flexibility -- users can achieve different levels in different content areas according to their unique needs and resources. Importantly, the team wanted the Levels to focus on practices, not policies or workflows, in order to allow immediate implementation. In this same spirit, the current Levels chart is considered "Version One," recognizing that a core feature of the Levels project is its community- and use-driven evolution. The final goal of the Levels team was to design a resource that, like digital stewardship itself, will adapt and improve over time. The ongoing, dedicated support of the NDSA membership and the broader community will be fundamental to the continued development of the Levels of Digital Preservation.

Comparison with Existing Models

The Levels team reviewed existing digital preservation tools and documents when proposing the NDSA Levels work. The team felt that nothing available as of spring 2012 specifically addressed the need for practical technical guidance when a preservationist takes preliminary first steps or builds on steps already taken. After the project was begun, the team did a more systematic review of the other tools to document the niche into which the NDSA Levels fit. Much of the existing work on models of digital preservation aims to advise a management audience rather than a technical audience and addresses the holistic digital preservation program. In contrast, the NDSA Levels chart assumes an audience of digital preservation practitioners, people who will be responsible for taking practical, hands-on action. The NDSA Levels chart offers activities that can progressively reduce various risks to digital materials, so the unit of analysis is not the whole digital preservation program, but rather the specific materials to be preserved.

In 2003, when Nancy McGovern and Anne Kenney wrote, "The Five Organizational Stages of Digital Preservation," many organizations seemed paralyzed and unable to take the first steps toward a digital preservation program because they were waiting for a good technical solution to appear. McGovern and Kenney wrote that organizational readiness rather than technology is actually the main impediment to progress in digital preservation at many institutions, so their paper addresses the stages in development of an organizational program to sustain digital preservation. [2]

Much of the work in the following years also addressed organizational support for digital preservation, including TRAC [3]; other recent products that discuss levels of preservation are based closely on TRAC and inherit the holistic program focus of assessment. Charles Dollar and Lori Ashley's "Digital Preservation Capability Maturity Model," [4] for example, uses assessment criteria drawn from TRAC and related products in a comprehensive and rigorous assessment of the levels through which a digital preservation program should evolve.

These products are extremely useful for managers and administrators who are designing programs and planning for their evolution. However, they provide little practical guidance to the practitioner figuring out what steps to take to decrease the risk to the digital material in his or her custody. While in 2003 McGovern and Kenney were concerned that organizational readiness was a major stumbling block to starting digital preservation work, the NDSA Levels team still saw many institutions of all types struggling to get started in 2012 and proposed a return to a focus on the technical steps in preservation. Perhaps both types of guidance documents together can help institutions launch robust digital preservation programs starting from modest but first steps.

The Levels team was not the only group to place renewed focus on practical technical steps in 2012. OCLC Research also came out with a paper on a similar theme, "You've Got to Walk Before You Can Run: First Steps for Managing Born-Digital Content Received on Physical Media." [5] This paper bears the closest resemblance to the NDSA Levels of Digital Preservation, and in fact some of its technical recommendations are the same as those in the NDSA chart's guidance. The OCLC document has a narrower scope, however. OCLC Research limits its scope to born digital content on physical media, and addresses only the first steps, not a sequence of steps that can progressively reduce risk to digital material.

Given this survey of existing and emerging tools, the NDSA team believes its Levels of Digital Preservation fills a need that is not specifically addressed anywhere else.

Levels of Digital Preservation

Version 1

It is expected that the Levels of Digital Preservation will be updated over time as additional feedback is received, experience is gained implementing its recommendations and as empirical research provides detailed information about data loss. For this reason, each iteration of the Levels will be versioned. Version 1 is shown in Table 1.

Table 1: Version 1 of the Levels of Digital Preservation

	Level 1 (Protect your data)	Level 2 (Know your data)	Level 3 (Monitor your data)	Level 4 (Repair your data)
Storage and Geographic Location	- Two complete copies that are not collocated - For data on heterogeneous media (optical discs, hard drives, etc.) get the content off the medium and into your storage system	- At least three complete copies - At least one copy in a different geographic location - Document your storage system(s) and storage media and what you need to use them	- At least one copy in a geographic location with a different disaster threat - Obsolescence monitoring process for your storage system(s) and media	- At least three copies in geographic locations with different disaster threats - Have a comprehensive plan in place that will keep files and metadata on currently accessible media or systems
File Fixity and Data Integrity	- Check file fixity on ingest if it has been provided with the content - Create fixity info if it wasn't provided with the content	- Check fixity on all ingests - Use write-blockers when working with original media - Virus-check high risk content	- Check fixity of content at fixed intervals - Maintain logs of fixity info; supply audit on demand - Ability to detect corrupt data - Virus-check all content	- Check fixity of all content in response to specific events or activities - Ability to replace/repair corrupted data - Ensure no one person has write access to all copies
Information Security	- Identify who has read, write, move and delete authorization to individual files - Restrict who has those authorizations to individual files	- Document access restrictions for content	- Maintain logs of who performed what actions on files, including deletions and preservation actions	- Perform audit of logs
Metadata	- Inventory of content and its storage location - Ensure backup and non-collocation of inventory	- Store administrative metadata - Store transformative metadata and log events	- Store standard technical and descriptive metadata	- Store standard preservation metadata
File Formats	- When you can give input into the creation of digital files encourage use of a limited set of known open formats and codecs	- Inventory of file formats in use	- Monitor file format obsolescence issues	- Perform format migrations, emulation and similar activities as needed

General Structure of the Levels: Categories and Tiers

The overall structure of the chart is progressive -- the actions in the first level are either necessary prerequisites for those in the second to fourth levels or are themselves the most pressing activities to accomplish first. The five general categories (Storage and Geographic Location, File Fixity and Data Integrity, Information Security, Metadata and File Formats) were agreed upon early in the project. These areas were identified by the Levels team as the broad conceptual areas of focus for thinking through technical and immediate threats to digital preservation. In this respect, these categories are the categories that the subject matter experts on the Levels team use to categorize their own work. This is how the team members describe the risks and threats that they work to mitigate.

In relation to other work, some readers might ask why issues with rights and/or policies have been excluded. From the start, the team was primarily concerned with technical issues; the goal was to identify the technical functions and features one would want to see occurring somewhere to ensure long term access to digital content, not the social or legal structure that would be in place to sustain those activities. Again, the goal of this project is not to

provide a plan for digital preservation but to provide a chart to help anyone interested in long term access to digital information evaluate how they are doing in terms of mitigating risk of loss and identify concrete technical next steps they can take to move all or part of their operation to the next level.

Broadly speaking, as one moves up each of the tiers from Level 1 to Level 4, one is moving from the basic need to ensure bit preservation towards broader requirements for keeping track of digital content and being able to ensure that it can be made available over longer periods of time. While the names for the five general categories in the grid were agreed upon early in this work, there was difference of opinion on the extent to which the labels for each of the levels (Protect Your Data, Know Your Data, Monitor Your Data, and Repair Your Data) should be included. Some in the team wanted to leave the labels out and strictly work to organize the document according to the perceived biggest risks to mitigate loss. Others in the group felt that the labels helped conceptually organize the grid and helped to explain the general overarching goals of each level. The conceptual value of the categories won out, and remains part of the chart. However, it is important to note that the labels applied to each level are rough characterizations and not edicts about exactly what should go in a given level. In any case when the conceptual purity of ordering particular activities was in contest with the pragmatic realities of what the team thought needed to be addressed first, the team sided with the pragmatic action over conceptual purity.

Detailed Explanation of Categories and Tiers

In what follows the reasoning behind each of the particular features of each individual level is briefly articulated.

Storage and Geographic Location

The first factor on the grid focuses attention on the storage of digital information. As one moves up the levels one is keeping additional copies, which helps to hedge against threats of loss due to bit rot and failures in storage media and systems. Similarly, as one moves up the levels one incorporates additional geographic locations to hedge against regional threats (like natural and manmade disasters) to storage systems. At the very base level, the first step one should take to ensure access to materials in the future would take is to create a second copy. Thus that requirement is the first item on the chart.

Aside from these two general trends across this category, the first level asks that one get data that comes in on heterogeneous media (optical disks, external hard drives, etc.) off of the removable media and into a storage system. The team identified this as an essential first step, as this kind of heterogeneous storage media is at risk of failure and requires significant manual effort to ensure data integrity. Further, this first step is necessary as a means to enable the kinds of preservation action required in many other parts of the levels document. The term "storage system" is intentionally vague as the team did not want to focus too much on any particular storage technology. Given the nature of the full set of requirements in the levels document, storage system should generally be understood as either a nearline or online system using either all spinning disk or some combination of spinning disk and magnetic tape.

Levels 2, 3, and 4 have additional requirements that focus on ensuring the longevity of storage systems: first requiring documentation of the system, then requiring an obsolescence monitoring process for storage systems and media and finally a comprehensive plan for keeping content on currently accessible media or systems. The intention in making these steps incremental is largely to spread out a set of activities that would all be nice to have but which become increasingly complex and require the work of the previous level to be possible.

File Fixity and Data Integrity

One of the most essential components of digital preservation is being able to attest to the fixity and integrity of the materials being preserved. This is a foundational component of digital preservation, but for many organizations checking the fixity of content remains a challenge. The goal of this category is to provide a series of steps that will take an organization to a stage where it is acting robustly to ensure the fixity of their content.

At the first level, the recommendation is simply to check the fixity on ingest if fixity information is provided for content (likely MD5 or SHA-1 cryptographic hashes) or to generate fixity information if none were provided. This is a necessary first step for an organization to validate that the content they preserved is what they intended to preserve. Many organizations are accomplishing this by making use of tools like Bagger [6] or usage of the BagIt specification [7] to package digital content.

From there, the next levels bring in additional activities to help further ensure the integrity of content. Most notably, Level 2 requires fixity checks on all ingests, and Levels 3 and 4 move into increasingly strong requirements for ongoing checking of digital content. The requirements in Levels 3 and 4 shift from placing trust in the quality and performance of particular storage media and shift to thinking of preservation as being ensured through repeated ongoing checking of content. This provides the added level of assurance and the ability to confidently assert the fixity of content one is stewarding.

Information Security

The information security section focuses primarily on understanding who has access to content, who can perform what actions on that content and enforcing these access restrictions. It starts with basic and simple steps to identify who can do what to the content. This is essential as without having procedures in place to restrict what can be done with content, one invites the risk of someone incorrectly deleting content. From there, Level 2 progresses to access restrictions. Level 3 suggests keeping logs of actions, which helps to bring an organization's approach in line with archival best practices. Level 4 brings in the added requirement of auditing logs of those actions which helps to double check that intended activities and actions are actually happening.

Like many of the other sections, these levels were arrived at largely by establishing what one would need to have in place as a prerequisite for more advanced requirements and calibrated to minimize risk in relation to the other risks the team perceived across the other categories.

Metadata

While issues related to metadata appear in many of the other levels, it was decided that it was critical to give the issue its own row in the chart. The team defines metadata broadly, including everything from inventory information about the location of files, broader sets of administrative metadata (for example when and how it was created, and who can access it), transformative metadata documenting and logging events that have resulted in changes in objects, to technical and descriptive metadata, and ultimately preservation metadata.

In organizing the levels in the order presented the team suggests the most essential metadata at the lower levels and at higher levels, the additional layers of metadata that will make content both better protected and more identifiable and accessible. It is worth noting, that in most systems nearly all of this metadata (with the exception of descriptive metadata) can and should be generated and processed computationally and not manually.

File Formats

Digital objects are intimately dependent on the structure and nature of their file formats. The file formats section of the chart is the section that underwent the most change and revision in the process of public review of the Levels. The recommendation the team settled on allows for the possibility that not all formats will need migration or emulation, but that at Level 4, preservation interventions will be actively pursued for any formats that require them.

The first level simply suggests that organizations, when possible, encourage the use of limited sets of known and open file formats. This is particularly the case in situations where an organization is digitizing material and has considerable say in what formats to use. For that kind of work, authoritative sources such as the Federal Agencies Digitization Guidelines [8] should be consulted for additional file format advice. With that noted, in many other contexts, including collecting born digital archival material from heterogeneous tangible media or web archiving it would not be feasible to force any changes in file formats as a basic requirement.

Successive levels begin to document the formats in use, monitor them for obsolescence issues, and ultimately to engage in migrations, support emulation, or look into other modes of ensuring that preserved content is usable and accessible in the future. The team placed actions based on format obsolescence in the fourth level for several reasons. First, while obsolescence is a formidable problem, it requires one to have made it through the hurdles of basic bit preservation and data management. In short, if a file cannot be opened, it is still a file in one's possession. Aside from this, as issues around migration and emulation are areas of extensive ongoing research and development it is likely that while an organization is addressing issues related to the first three levels there will be substantive advances in working with some of the file formats they are stewarding. It's better to get one's house in order first and then join in ongoing discussions of when particular approaches to migration and emulation are applicable to particular goals.

Using the Guidelines

The initial use case envisioned by the Levels team was as a reference for organizations to consult when prioritizing enhancements to digital preservation systems. Although the guidelines are still relatively new, they are proving not only to be useful for that purpose, but also in unanticipated ways. Other possible uses for the preservation levels are described in this section.

Use: Identify where there is and isn't general consensus in the preservation community

To get to this first version of the Levels, there was a great deal of discussion and debate among the NDSA members who produced it. Numerous versions of the Levels were produced and modified based on these discussions. During the course of this work, the Levels evolved into a product that still had a few items without unanimous support, but in general the team was behind the guidelines. After the Levels were published to the Web, another round of discussion and debate ensued, this time including practitioners from around the world, over important topics such as the usefulness (or not) of validating file formats, whether or not format normalization on ingest is an activity we should all be striving to implement, and how many different copies need to be in locations with different disaster threats. Where there seemed to be consensus, the suggestions were incorporated into what became version 1. It is expected that as the Levels are reviewed and debated in additional forums over time, and the consensus is incorporated into revisions, they will continue to reflect the community's digital preservation best practices.

Use: Educate and develop guidelines for content creators and contributors

A thorough reading of the Levels chart reveals that there is a direct relationship between the activities and efforts of content creators (e.g. use of open formats and codecs, degree of content description) and the level of preservation service that can be provided for the content. For example, if content creators supply some descriptive metadata about the content, there is the possibility that the content can receive Level 3 service. An organization could use this chart directly as an educational tool or transform its information into guidelines to show content creators how they can contribute to better preservation for their content.

Use: Validate preservation guidance given locally

One person giving feedback on version 1 of the Levels said, "It's the kind of thing we need at the NPS to be able to demonstrate to practitioners and managers that we aren't just 'making things up' when it comes to preservation recommendations." [9] Because the guidelines presented in the Levels chart were produced by digital preservation practitioners, it is likely that they will intersect in whole or part with recommendations and advice given locally within our institutions. Where this occurs practitioners can point to the Levels chart as evidence that their local advice is in sync with the larger preservation community's thinking and practices.

Use: Develop requirements for third-party preservation service providers

The Levels chart defines some of the core minimum requirements for preservation. These guidelines could be re-expressed from a content holder's perspective as requirements when soliciting or negotiating preservation services from external companies or organizations. For example an RFP could specify that all of the activities described in the File Fixity and Data Integrity row be implemented.

Use: Assess compliance with preservation best practices and identify key areas to improve

The Levels chart looks deceptively simple but in actuality it can support multiple types of assessments. The unit of assessment is flexible. It can be used to assess the preservation capabilities of an entire preservation repository or one component of the repository (e.g. storage). Or it can be used to assess the degree of preservation received by particular collections or streams of content. The portion of the chart referenced can vary also. The Level 1 column can be used alone to reference recommended first steps. Or a single row could be referenced to drill down in a particular area (e.g. just "Storage and Geographic Location"). Alternatively the full chart could be used to do an overall assessment.

Unlike some of the other assessment models, the result of an assessment using the Levels isn't likely to be a single score, e.g Level 2. The chart is composed of five different functional areas (Metadata, etc.) that are not necessarily correlated within a given implementation. For example an institution may find that their repository is at Level 2 for Information Security but Level 3 for metadata. In addition, within a functional area, the levels do not in all cases build on prior levels. An institution could find that it complies with Level 3 for metadata but not Level 2. Finally, many of the cells contain multiple guidelines. An institution may find that it only partly complies with Level 2 for File Fixity and Data Integrity. For these reasons the levels are better viewed as progressive stages or levels of service instead of "scores". They can be used to identify broad areas to improve, identify areas of service excellence and pinpoint specific enhancements to make in order to comply with best practices. In addition they can be used to demonstrate the effect of large enhancement projects and to track progress over time.

The Levels team is hoping to learn how others are using the Levels to perform assessments of their preservation repositories. One method that has proven to be useful in one of the team members' institutions is described here. Within this institution, a large repository enhancement project (called project x here) is in progress. Each of the functional areas was reviewed sequentially from Level 1 through Level 4. For each cell, one of 5 values was written to a summary table:

- PASS - means that we already are doing these activities
- PASS (improved after project x) - means that we are already doing these activities but we will have an even better implementation after project x is complete
- PASS (after project x) - means that we will be doing these activities after project x is complete
- INCOMPLETE - means that we are doing the activity somewhat but not in an entirely satisfactory way
- FAIL - means that we are not doing this activity

As a result of coding each cell with one of these values and coloring the cells to make the patterns obvious visually, the summary table provides a powerful visualization of not only how the repository compares to this set of best practices, but also the effect of the enhancement project in progressing to where we want to be. Often enhancements to preservation systems can be largely "behind the scenes" so visualizations like this summary table provides can help justify the costs and effort by communicating the value to the organization. Information about additional purposes the Levels of Digital Preservation could serve or examples of actual use of the levels would be useful feedback.

Feedback and Future Work

As noted throughout this paper, the Levels were developed in a collaborative environment and they are still a work in progress. The Levels team actively invites comments and suggestions for how to improve the document. This paper and the associated Archiving 2013 presentation are mechanisms for the Levels team to spread the word further and invite more experts in the field to review and help refine the document. Levels team members are presenting the levels to other professional organizations and requesting their input during the course of 2013.

Readers can e-mail comments and suggestions to the paper's authors at the addresses provided below. Revisions will continue until the Levels stabilize at a broad consensus view of the progression of technical steps recommended for decreasing the risk to digital materials. Comments received by August 31, 2013 will be considered in drafting the next version of the document.

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In addition to revising the Levels chart, the project team plans several other types of future work. Based on earlier feedback, the team plans to incorporate definitions of terms used in the chart, and resources available to plan or execute each step. The team is considering including information about how the Levels might be used (as described above) in the document itself. The team would also like to provide a version of the chart online that allows the user to drill down on each cell of each level to access definitions and resources relevant to that topic. Feedback on these plans would be welcome as well.

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