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Digital Preservation Metadata Management as a Mechanism to Ensure Sustainable Access: A Field Study at the National Retirement Fund Archives (CNR) -Oum El Bouaghi Algeria-

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Abstract:

This study explores digital preservation metadata management at the National Retirement Fund (CNR), Oum El Bouaghi agency. Using a descriptive-analytical approach with interviews and observation, the research reveals a reliance on the (STAR) system but a lack of standardized preservation policies. Strategies are limited to backup (50%) and migration (33%), ignoring emulation. Despite having robust infrastructure, the metadata applied does not adhere to international standards like PREMIS, relying on implicit fields. This endangers long-term record authenticity. The study recommends adopting global

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standards and staff training to mitigate technological obsolescence.

Keywords : Digital Preservation ; Preservation Metadata ; CNR ; STAR System ; Sustainable Access.

1. INTRODUCTION

In the wake of rapid digital transformation, archival institutions are confronted with a dual challenge : managing the exponential growth of digital information while ensuring its long-term viability. Digital preservation is no longer a mere technical storage process ; rather, it has evolved into a complex intellectual and technical endeavor fundamentally rooted in "Metadata." Often referred to as the "DNA" of digital records, metadata documents the context, structure, and technical provenance of a document, ensuring its integrity over time.

This study focuses on the National Retirement Fund (CNR) in Oum El Bouaghi, Algeria, as a model for institutions heavily reliant on automated systems for managing retiree files. This reliance raises critical questions regarding the readiness of its digital archives to withstand the challenges of technological obsolescence.

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1.1 The Problem Statement

The core problem of this study revolves around the following central question :

To what extent does digital preservation metadata management at the National Retirement Fund (CNR) archives—Oum El Bouaghi agency—contribute to securing sustainable access to digital assets and protecting them from obsolescence **?**

From this central question, the following sub-questions emerge :

- What is the scientific conceptualization of digital preservation metadata, and what pivotal role does it play in guaranteeing the long-term continuity of access to information within the digital environment ?
- What types of metadata are currently implemented within the fund's information system (STAR) ?
- Does the existing infrastructure meet the necessary requirements for implementing long-term digital preservation ?
- What preservation strategies (Backup, Migration, Emulation) are employed to ensure the longevity of digital records ?
- To what extent does the current metadata practice align with international preservation standards (such as the OAIS reference model) ?

1.2 Study Objectives

The study aims to achieve the following objectives :

- **To explore the conceptual framework of digital preservation metadata** and underscore its pivotal role as a fundamental mechanism for documenting and ensuring the long-term sustainability of digital objects.
- **To examine the current state of metadata generation and implementation** within the institution's archival information system (STAR).
- **To evaluate the technical infrastructure** and the hardware/software capabilities specifically allocated for digital preservation tasks.
- **To assess the efficacy of the implemented preservation strategies** and their impact on ensuring the continuous retrieval and usability of digital information.
- **To conduct a gap analysis** between current organizational practices and international standards (such as OAIS and PREMIS), while providing strategic recommendations for systemic enhancement.

1.3 Study Hypotheses

- **Hypothesis 1 :** Preservation metadata serves as the foundational pillar for safeguarding the authenticity, integrity, and renderability of digital records throughout their lifecycle.
- **Hypothesis 2 :** The institution primarily relies on implicit metadata schemas (mainly administrative and descriptive)

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embedded within its automated system, rather than dedicated preservation-oriented metadata.

- **Hypothesis 3 :** The National Retirement Fund (CNR) possesses an adequate technical infrastructure for storage ; however, it lacks a standardized, comprehensive policy framework for digital preservation.
- **Hypothesis 4 :** The institution favors traditional preservation strategies (such as routine backups) over more sophisticated technical interventions (such as emulation or proactive migration).

2. The Pivotal Role of Preservation Metadata in Ensuring Sustainable Accessibility

2.1. The Concept of Digital Preservation Metadata Management

A. Digital preservation metadata : is defined as a comprehensive information infrastructure associated with a digital object, specifically engineered to ensure its long-term sustainability and continuous accessibility. Beyond mere description, this metadata provides a critical historical context (provenance), documenting the object's lifecycle, technical creation environment, and subsequent modifications. It also encompasses essential data regarding intellectual property rights and the technical specifications required for rendering and viewing the content, thereby ensuring the object's integrity and readability over time.[1]

Functionally, preservation metadata serves as a "future-proofing" roadmap, safeguarding the intellectual and cultural value of

digital heritage for subsequent generations. It constitutes the foundational framework that supports the core pillars of digital longevity, ensuring that digital entities remain :

- **Viable :** Physically intact and accessible on storage media.
- **Understandable :** Meaningful to future users and systems.
- **Renderable :** Capable of being displayed and processed by evolving software and hardware.
- **Identifiable :** Distinctly recognized through unique identifiers.
- **Authentic :** Verifiable genuine and protected from unauthorized alteration. [2]

B. Concept of Digital Preservation Metadata Management : Digital preservation metadata management is defined as a strategic discipline encompassing the processes, responsibilities, and technologies required to ensure the quality and integrity of metadata describing an organization's information assets. By ensuring metadata quality, this practice adds significant value to institutional information and serves as the cornerstone of broader data management frameworks, including data governance, architecture, and analytics.[3]

C. The Reference Model for an Open Archival Information System (OAIS)

To understand the gap in the current practices at the National Retirement Fund (CNR), it is essential to frame the study within the ISO 14721 standard, known as the

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OAIS Reference Model. This model provides a conceptual framework for an archival system dedicated to preserving and maintaining access to digital information over the long term. The OAIS model identifies six functional entities that remain absent or partially implemented in many Algerian institutions :

- **Ingest :** The process of accepting information from producers and preparing it for storage. [4]
- **Archival Storage :** The services and functions for the storage, maintenance, and retrieval of Archival Information Packages (AIP).
- **Data Management :** The services and functions for populating, maintaining, and accessing descriptive information which identifies and documents archive holdings.
- **Administration :** The services and functions for the overall operation of the archive system.
- **Preservation Planning :** The services and functions for monitoring the environment of the OAIS and providing recommendations to ensure that the information stored in the OAIS remains accessible to the Designated Community.
- **Access :** The services and functions that support consumers in determining the existence, description, location, and availability of information stored in the OAIS and allowing them to request and receive

information products.[5]

The absence of a clear mapping of these functions within the CNR's digital strategy explains the reliance on simple "backups" rather than a comprehensive preservation plan.

2.2. The Significance of Metadata Management

Metadata Management serves as a fundamental catalyst for enhancing organizational operational efficiency in the digital era. It enables the extraction of actionable insights and elucidates complex interrelationships within data landscapes. The significance of this discipline can be synthesized into the following key dimensions :

- **Enhancing Data Integrity and Quality :** Strategic metadata management ensures consistency in data definitions, fostering accuracy and comprehensiveness. This mitigates redundancy, eliminates contradictions between disparate information sources, and significantly optimizes retrieval effectiveness.
- **Operational Cost Optimization :** It reduces the financial burden by streamlining data requirement identification. Without centralized metadata management, organizations are forced to duplicate efforts for every new project, whereas a robust framework promotes resource reusability and time efficiency.
- **Increasing Productivity and Decision-Making Agility :** It facilitates real-time, high-precision data

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analysis. By providing a clear understanding of data value and completeness, metadata management accelerates workflows and empowers evidence-based decision-making.

- **Facilitating Change Management :** Metadata management provides critical tools for **impact analysis**. It allows organizations to evaluate how evolving business requirements affect data structures, thereby enhancing organizational agility and adaptability to change.
- **Promoting Data Sharing and Inter-departmental Synergy :** It fosters a culture of knowledge exchange by breaking down "data silos." This ensures that information assets are accessible across various departments, enhancing collective collaboration.
- **Data Protection and Cybersecurity :** It plays a pivotal role in safeguarding information assets against unauthorized access, thereby mitigating the risks of data breaches, leaks, and cyber-attacks.[6]

Based on the aforementioned, metadata management is indispensable for governing institutional data. It encompasses retrieval, quality assurance, accessibility, description, and preservation. By providing a framework for managing organizational transitions effectively, it fosters a "trustworthy data environment," ultimately driving institutional productivity and competitiveness with optimized costs and minimal timeframes.

2.3. How Digital Preservation Metadata Management

Facilitates Sustainable Access to Digital Entities

A. Digital preservation metadata management, guided by the OAIS (Open Archival Information System) reference model, plays a decisive role in achieving sustainable access. It fulfills six core functions that ensure digital entities remain viable, meaningful, and accessible across generations :

- **Ensuring Understandability :** Metadata ensures that digital data remains interpretable over time by providing essential contextual information. This includes Provenance (creation history and purpose), Lifecycle Events (modifications), and Agent Information (stakeholders involved), preventing data from becoming obsolete or meaningless.
- **Maintaining Authenticity and Reliability :** Sustainable access is predicated on trust. Metadata management safeguards the integrity of digital objects through Checksums (fixity checks) and Digital Signatures, ensuring that the data has not been altered or corrupted by unauthorized actions.
- **Persistent Identification :** This function utilizes Object Identifiers (such as DOIs or PIDs) to uniquely distinguish digital entities. This ensures that resources remain discoverable and linkable, avoiding the "broken link" phenomenon in long-term repositories.

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- **Facilitating Renderability and Portability :** To achieve sustainability, data must move seamlessly between heterogeneous systems. Metadata documents Format Specifications, Internal Relationships, and Environment Dependencies (OS, software requirements), ensuring the object can be displayed and processed regardless of technological shifts.
- **Ensuring Bit-level Viability :** This function focuses on the physical survival of digital data. It manages information regarding Storage Media and Physical Locations, ensuring that the bitstream remains intact and accessible on current hardware.
- **Enabling Continuous Accessibility :** The ultimate goal of these combined functions is to guarantee that digital entities are discoverable and usable at any time, overcoming the challenges of technological obsolescence.[7]

By integrating these functions, digital preservation metadata serves as the foundational infrastructure that guarantees the long-term integrity, interpretability, and sustainable accessibility of digital heritage

B. The Role of Metadata in Ensuring the "Authenticity" of Digital Entities :

In the context of digital archiving, authenticity denotes the assurance that a digital object is precisely what it purports to be and has remained untampered with throughout its lifecycle.

Metadata management operationalizes this integrity through the following mechanisms :

- **Event Logging (Audit Trail) :** Maintaining a comprehensive chronological record that documents every procedural action taken upon the digital entity, including access permissions, modifications, and migration processes.
- **Checksums (Fixity) :** Utilizing unique cryptographic hash values that function as a "digital fingerprint" for the file. Any alteration at the bitstream level—however infinitesimal—will result in a discordant checksum, providing an immediate alert to potential data corruption or unauthorized intrusion.
- **Provenance :** Preserving a robust historical and contextual record that links the digital object to its original creator and production environment. This ensures the maintenance of the Chain of Custody, which is vital for verifying the source's credibility[8].

3. Field Study : The Reality of Digital Preservation at the National Retirement Fund (CNR)

3.1 Study Scope and Rationale : Methodology and Instruments

This study was conducted at the National Retirement Fund (CNR) – Oum El Bouaghi Local Agency. This institution was specifically selected based on several strategic considerations :

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- **Massive Digital Document Workflow :** The substantial volume of digital document flow generated by the daily processing of retiree files.
- **Early Technological Adoption :** The institution's early integration of digitization and automated workflows (specifically the STAR system), providing a fertile environment for testing digital preservation hypotheses.
- **Information Sensitivity :** The critical nature of the data (involving legal, financial, and social rights), which necessitates robust, secure, and long-term preservation.

To achieve the research objectives, a descriptive-analytical approach was employed, utilizing the case study method. This approach is deemed most appropriate for investigating complex phenomena within their real-life context.

The study targeted a purposive sample of the staff directly responsible for the archival and digital systems (n=6), distributed as follows :

- **Four (4) Archivists :** Responsible for the processing and management of archival collections.
- **Two (2) IT Engineers :** Responsible for server maintenance and database administration.

To ensure the **validity and reliability** of the findings, two primary tools were utilized :

- **Structured Interviews :** Conducted with the participants to gauge their awareness of digital preservation concepts, evaluate current policies, and identify the technical and administrative challenges associated with metadata creation.

- **Direct Observation :** Utilized to conduct a technical inspection of The Server Room To verify the existence of storage infrastructure (such as Storage Arrays/SAN) and evaluate the physical environment for digital preservation. STAR System Interfaces To analyze the metadata fields facilitated by the system and observe the electronic encoding, indexing, and tracking of digital records.

Fig.1. Front Facade of the National Retirement Fund (CNR) – Oum El Bouaghi Agency

Source : Researchers' photograph, field visit

3.2 Technical Analysis of the Technological Environment : The STAR System and Infrastructure

The field visit and direct observation revealed that the technological ecosystem at the CNR Oum El Bouaghi agency is built upon two fundamental pillars : the application software and

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the technical hardware. The following is a detailed analysis of these components :

A. The STAR Information System :

The institution relies exclusively on the "System for Automated Retirement Processing", known by its acronym STAR. This is a centralized system developed by the General Directorate and implemented locally to manage the administrative lifecycle of retiree files.

Upon examining the system's interfaces, it was observed that STAR functions beyond mere pension calculations ; it acts as an implicit Electronic Document Management System (EDMS). Its core archival functionalities include :

- **Workflow Management :** Facilitating the transition of records between various departments (from reception and liquidation to final archiving).
- **Digital Repository :** Storing digital surrogates of evidentiary documents and linking them to the descriptive metadata of the retiree.
- **Audit Trail and Tracing :** Providing a real-time mechanism for tracking file movement, identifying their current location, and assigning departmental responsibility.

B. Infrastructure and Hardware :

To ensure system stability and accommodate massive data growth, the agency possesses a robust technical infrastructure, centered around the Storage Array (Baie de stockage).

This hardware serves as the backbone for Bit-level preservation (the physical preservation of data). The researchers observed that these units are housed within a dedicated **Server Room** that adheres to standard preservation environmental controls, including :

- **Continuous Cooling Systems :** Maintaining a stable temperature (approximately 20°C) to prevent thermal degradation of the storage disks.
- **Uninterruptible Power Supply (UPS) :** Ensuring power stability and preventing sudden data loss due to electrical fluctuations.
- **High Storage Capacity :** Designed to accommodate the exponential growth of the institution's digital assets.

Fig.2. Storage Array (Baie de stockage) at the Agency's Data Center

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Source : Researchers' photograph, field visit

3.3 Presentation and Discussion of Results

A. Applied Digital Preservation Strategies

Field data revealed the institution's strategic trends in safeguarding its digital collections. The findings are summarized in the following table :

Table 1. Distribution of Adopted Digital Preservation Strategies at CNR Archives

Strategy	Frequency	Percentage (%)	Field Interpretation
Backup	3	50%	The dominant strategy aimed at ensuring Business Continuity.

Migration	2	33.33%	A technical procedure executed during server or operating system upgrades.
Refreshing / Media Care	1	16.66%	Periodic checks of storage media integrity.
Emulation	0	0%	Total absence of awareness regarding this advanced technique.

Source : Prepared by the researchers based on field study data (2024).

The results clearly indicate a dominance of a "Security-driven Logic" over an "Archival Preservation Logic." The institution's 50% reliance on backups reflects a prioritization of disaster recovery (e.g., disk failure or accidental deletion), a concept professionally categorized as "Passive Preservation."

Conversely, the total absence of Emulation (0%) and the limited scope of Migration highlight the system's vulnerability to Technological Obsolescence. In the long term, the institution may find itself possessing "intact files" (secured via backups) that are nonetheless "unrenderable" due to the extinction of the software environments required to open them. This finding corroborates established digital preservation literature, which warns that backing up bits, without active management of file

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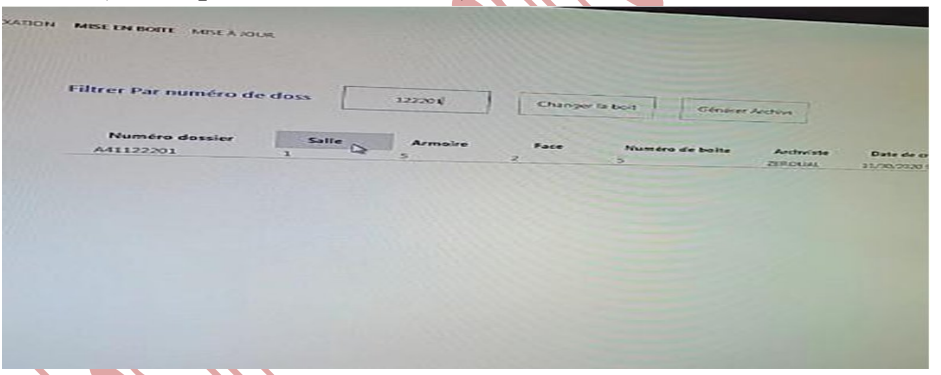
formats and software dependencies, is insufficient to guarantee sustainable access.

B. The Status of Metadata in the STAR System

Through an in-depth analysis of the technical specifications of the **STAR system**, the researchers examined how the platform handles metadata. The following figures illustrate the core findings :

Fig.3. Search and Retrieval Interface in the STAR System (Descriptive Fields Model)

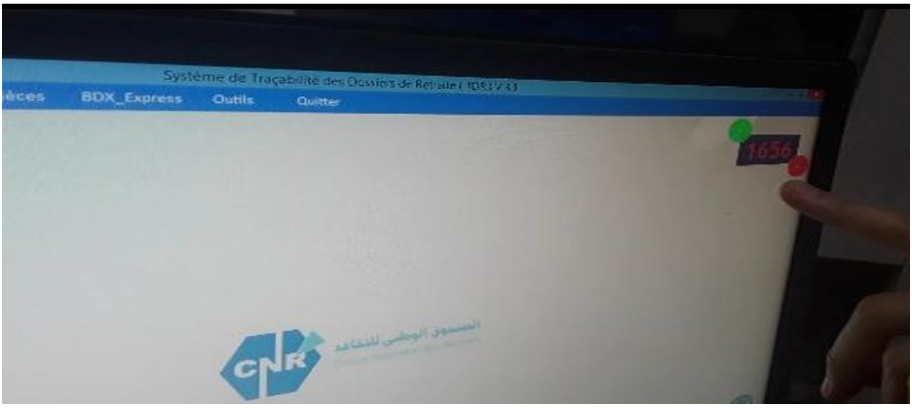


Source : System screenshot, CNR (2024).

Figure (3) demonstrates that the system relies on traditional descriptive metadata (e.g., file number, name, and date). While these fields are sufficient for rapid administrative retrieval, they lack the technical preservation metadata mandated by international standards such as PREMIS—specifically elements related to the computing environment, compression algorithms, and encoding history. This deficiency indicates that the system is

designed for immediate informational consumption rather than the long-term longitudinal transmission of digital assets to future generations.

Fig.4. File Tracking (Tracing) Mechanism and Color Coding in the System



Source : System screenshot, CNR (2024).

Figure (4) highlights a significant strength of the system : the automatic generation of Event/Context Metadata. The color-coded status indicators (e.g., green/red) and the precise timestamping of records as they enter or exit the archive constitute a practical application of the digital "Chain of Custody" concept. This mechanism ensures a baseline of reliability and integrity, protecting records from undetected tampering and documenting their administrative provenance.

3. Discussion of Results in Light of Hypotheses

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Based on the empirical analysis and its alignment with the theoretical framework, the four study hypotheses are discussed as follows :

- ***Discussion of the First Hypothesis: The Pivotal Role of Metadata***

The study validated this hypothesis both theoretically and empirically. The literature review established that preservation metadata is the primary guarantor of longitudinal renderability. Field findings underscored that the system's current failure to provide standardized technical metadata (such as operating environment specifications) poses a genuine threat to future sustainable access. This confirms the archival axiom : the absence of metadata is effectively the absence of preservation.

- ***Discussion of the Second Hypothesis: Adoption of Implicit Metadata***

This hypothesis was fully substantiated. Technical examination of the STAR system's interfaces proved that the institution relies on embedded descriptive and administrative fields (e.g., name, date, ID, access permissions) integrated within the system's core architecture. While this implicit metadata satisfies current operational requirements, it lacks standardized structural schemas (such as XML or JSON) required for system-independent data migration—a critical factor for ensuring that records survive the systems that created them.

- ***Discussion of the Third Hypothesis: Infrastructure versus Institutional Policy***

Field observations (as seen in Figure 2) confirmed the existence of robust technical infrastructure, including advanced storage servers, which supports the first part of the hypothesis. However, the second part regarding the void in institutional policies was corroborated by interview data. The institution lacks a formalized Digital Preservation Policy that defines roles, responsibilities, and mandated file formats. Consequently, preservation efforts remain dependent on ad-hoc technical initiatives rather than a standardized, strategic institutional framework.

- ***Discussion of the Fourth Hypothesis: Dominance of Traditional Preservation Strategies***

Statistical results (Table 1) validated this hypothesis, showing that Backup strategies (50%) dominate the preservation landscape, while advanced interventions such as Emulation are entirely absent. This highlights a strategic orientation toward Information Security (preventing immediate data loss) rather than Archival Digital Preservation (mitigating long-term technological obsolescence). The institution is currently focused on "business continuity" rather than the "long-term evidentiary viability" of its digital assets.

5. Conclusion and Recommendations :

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A. Conclusion :

The study concludes that the CNR Archives in Oum El Bouaghi has made significant strides in digitizing its collections and implementing an automated system (STAR) that facilitates efficient information retrieval. However, actual Digital Preservation practices remain in an embryonic stage. The current ecosystem lacks the implementation of international preservation metadata standards (notably PREMIS) required to document the technical environment and provenance of digital files. The excessive reliance on routine backups, in the absence of a proactive File Format Migration strategy, exposes the institution's archival assets to the long-term risks of technological obsolescence.

B. Recommendations :

To bridge the gap between current practices and international standards, the study proposes the following recommendations :

- **Systemic Standardization :** It is imperative to upgrade the STAR system to support metadata harvesting and export in standardized schemas (such as XML) that are fully compatible with the PREMIS and OAIS models.
- **Professional Capacity Building :** Specialized training programs should be designed for both archivists and IT professionals. These programs must transcend "system operation" to cover the broader intellectual and technical

frameworks of Digital Archiving and lifecycle management.

- **Institutional Policy Formulation :** The institution should develop and adopt a formalized Digital Preservation Policy. This document must clearly define sustainable file formats for long-term retention (such as PDF/A), establish rigorous migration schedules, and delineate institutional responsibilities.

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6. Appendices : *Interview Guide*

The following questions were used during the semi-structured interviews with the archival and IT staff at the National Retirement Fund (CNR) - Oum El Bouaghi Agency.

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Axis	Questions
1. General Information	• What is your role and how many years of experience do you have in the archival center ? • What are the main types of documents managed by the center ?
2. Technical Infrastructure	• What types of storage media are currently used (Servers, Optical discs, Cloud) ? • Does the institution have a dedicated budget for upgrading storage hardware ? • What software system is currently in use for document management (STAR system, others) ?
3. Digital Preservation Strategies	• Is there a written policy for digital preservation in the institution ? • What strategies are applied to ensure long-term access (Backup, Migration, Emulation, Refreshing) ? • How often are backups performed, and where are they stored ?

4. Metadata Management	• What metadata standards are currently applied (Dublin Core, EAD, PREMIS, Local schema) ? • Does the system automatically capture technical metadata (file format, size, creation date) ? • Are there descriptive fields specifically for preservation purposes (e.g., checksums, format version) ?
5. Challenges and Human Resources	• What are the main technical challenges facing the digital archive ? • Is there a training program for staff regarding digital preservation standards ? • How does the institution deal with technological obsolescence of hardware or software ?