Challenges of the digital preservation of cultural heritage in Mexico: the Mexicana case

Desafíos de la preservación digital del patrimonio cultural en México: el caso de Mexicana

Desafios da preservação digital do patrimônio cultural no México: o caso da Mexicana

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ABSTRACT | Among the current challenges related to the digital preservation of heritage is the adoption of metadata normalization and standardization processes. This article discusses some challenges related to the digital preservation and dissemination of Mexico's cultural heritage in the project *Mexicana, el repositorio del patrimonio cultural de México* (Mexicana, the repository of Mexico's cultural heritage), four years after its publication. From this discussion and the comparison of the data processing of an emblematic Mexican object, the *Piedra de Sol*, we show the positive consequences of adopting specific standardization processes and of proposing a strategy of interoperability between repositories, as well as the results of standardization with metadata schemas. Some recommendations are also made to consolidate a future digital preservation program for Mexico's cultural heritage, which should be agreed upon by researchers, administrators, institution managers, and other agents in the cultural sphere.

KEYWORDS: linked open data; online digital collections; digital heritage; online cultural heritage; data standardization; standardization; information policies; GLAM.

RESUMEN | *Entre los desafíos actuales relativos a la preservación digital del patrimonio está adoptar procesos de normalización y estandarización de metadatos. En este artículo se discuten algunos desafíos relativos a la preservación digital y difusión del patrimonio cultural de México en el proyecto Mexicana, el repositorio del patrimonio cultural de México, a cuatro años de su publicación. A partir de esta discusión y de la comparación del tratamiento de datos de un objeto emblemático de México, la Piedra de Sol, se muestran las consecuencias positivas de adoptar procesos específicos de normalización, así como los resultados de la estandarización con esquemas de metadatos y de plantear una estrategia de interoperación entre repositorios. Asimismo, se enuncian algunas recomendaciones para consolidar un futuro programa de preservación digital de bienes de interés cultural de México, que debería consensuarse entre investigadores, administrativos, directivos de instituciones y otros agentes del sector cultural.*

PALABRAS CLAVE: *datos abiertos enlazados; colecciones digitales en la red; patrimonio digital; patrimonio cultural en la red; normalización de datos; estandarización; políticas de información; GLAM.*

RESUMO | Entre os desafios atuais relacionados à preservação digital do patrimônio está a adoção de processos de normalização e padronização de metadados. Neste artigo são discutidos alguns desafios relacionados à preservação digital e difusão do patrimônio cultural do México no projeto Mexicana, o repositório do patrimônio cultural do México, quatro anos após sua publicação. A partir desta discussão e da comparação do tratamento de dados de um objeto emblemático do México, a "Pedra do Sol", são mostradas as consequências positivas da adoção de processos de normalização específicos, bem como os resultados da estandardização com esquemas de metadados e de propor uma estratégia de interoperação entre repositórios. Além disso, são enunciadas algumas recomendações para a consolidação de um futuro programa de preservação digital de bens de interesse cultural do México, que deve ser consensuado por pesquisadores, administradores, diretores de instituições e outras pessoas no setor cultural mexicano.

PALAVRAS CHAVE: dados abertos vinculados; coleções digitais na web; patrimônio digital; patrimônio cultural na web; normalização de dados; estandardização; políticas de informação; GLAM

INTRODUCTION

Internationally, there are notable examples of repositories that contribute to the dissemination of digital objects and resources, as well as records of digitalized objects of great cultural interest. Among other, these include Europeana, which stores more than 62 million digital objects (DOs) from all over Europe, the Digital Public Library of America (DPLA), a resource that concentrates more than 44 million DOs from the United States, or the National Digital Library of India (NDLI), which indexes and stores more than 46 million academic publications, empirical data, and other DOs from India. In addition to these outstanding cases, many of the world's major museums have, in the last decade, made their collections public through their websites, such as the Musée du Louvre, The Hermitage Museum, The Metropolitan Museum of Art, the National Museum of Anthropology of Mexico, or the Museo del Prado. All of them could be characterized as open-access institutional repositories containing the digital objects they curate.

On the cultural heritage field in Mexico, leaving aside the National Museum of Anthropology, we must consider the cases, reviewed by González Mello (2018), of the Audiovisual Laboratory for Social Research (LAIS, by its Spanish acronym), the IIE's Musicat Project, the INAH's National Photo Library, the National System of Photo Libraries (SINAFO, by its Spanish acronym) or the National Sound Library, which have laid the foundations for the use of international metadata standards to manage or publish their collections.

Likewise, there are notable examples of institutional repositories such as the Unified System of Public Registry of Archaeological Zones and Historical Monuments, the INAH Media Library, and Mexicana, or the most recent examples published online: Memórica and Desobediente: the digital repository of the Museo Universitario del Chopo. The latter are characterized by being institutional repositories, but each of them has a specific thematic focus, and different access policies to their data.

Regarding the integration of Mexican repositories, a turning point is the creation, by presidential decree on December 17, 2015, of the Ministry of Culture (formerly the National Council for Culture and the Arts), which represented a new relationship between institutions of the cultural sector. Thus, decentralized government agencies, such as the National Institute of Anthropology and History (INAH, by its Spanish acronym) or the National Institute of Fine Arts and Literature (INBAL, by its Spanish acronym), decentralized public agencies, some national funds and trusts, and State-owned companies became dependent on the new Ministry of Culture ("Decreto por el que se reforman, adicionan…", 2015; Secretaría de Hacienda y Crédito Público, 2020). In general, the creation of the Ministry of

Culture, the new policies in the field of culture linked to its establishment, and the need to develop a national repository for the cultural sector were the conditions that led to the creation of Mexicana.

In Mexico, there are more and more web resources or repositories that, aligned with a global policy of open data and a local policy of free access to information ("Reglamento interior...", 2016), make cultural data freely available online.

Considering the growing interest of Mexican institutions to make their non-sensitive data accessible on the web, this paper makes a general review of concepts and processes related to the creation of digital repositories, paying specific attention to the challenges faced by the Mexicana project to propose some recommendations that in the near future will serve as a starting point for a digital preservation program of assets of cultural interest in the country. The Digital Agenda for Culture defines Mexicana as

> an indispensable vehicle to disseminate culture through a digital tool, where users from all over the world can access Mexico's valuable cultural heritage and expand the experience already provided by the cultural venues, and do so freely, universally and free of charge (Agenda Digital de Cultura, 2018, p. 9).

In other words, Mexicana's creation materializes the aspiration of having a federated repository of Mexico's cultural heritage, allied with other repositories at all levels of government, and with non-governmental cultural institutions that so wish (Agenda Digital de Cultura, 2018, p. 9).

THEORETICAL FRAMEWORK

A definition of the repository concept, restricted to the domain of textual objects (book and archive), states that "they are sets of documents collected, organized, and available electronically" (Silva & Tomaél, 2011, p.40). Authors such as Bekaert and Van de Sompel (2006) or Torres Vargas (2008) point out that, in addition to sets of documents, repositories compile digital objects such as teaching resources, artistic objects, museum objects, scientific datasets, or chemistry databases, among others. In a broad sense, "it is a network system that provides services related to a collection of digital objects" (Bekaert & Van de Sompel, 2006, p. 17).

The term repository is related to two dimensions that determine it: on the one hand, being a storage system, and, on the other, the type of things that it stores. For Torres Vargas (2008), the concept of repository as a storage system represents a change in the conception of databases (DB), which are usually kept in isolation, since it implies that they share groups of contents and shared services.

Regarding the things stored, a restricted stance assumes that they only group textual objects while, in a broad sense, it is thought that a repository concentrates different types of digital objects. For example, for Torres Vargas (2008) "among the various types of DOs [digital objects within repositories] are multimedia materials, which contain information in audio, images, video, and text" (p. 50).

For the purposes of this study, a repository will be understood as a system for the orderly storage of various collections of digital objects, managed by an institution, consortium, or government, whose purposes are to retrieve information for theoretical and applied research, and for teaching.

The literature divides repositories into two types: thematic and institutional. The former are limited to a specific domain of knowledge, while the latter concentrate digital objects produced in a specific institution (Azorín Millaruelo et al., 2014; Silva & Tomaél, 2011). This classification is not necessarily exclusive. An institutional repository, due to the interests and administrative scope of the agency that created it, can also be conceived as a thematic repository. Such is the case of the Mexicana project which, being an initiative of the Mexican Ministry of Culture, is institutional, but as its scope is limited to the domain of the country's cultural heritage, it could also be considered as a thematic repository.

On the other hand, there are those who distinguish two clear orientations of repositories, whether thematic or institutional, i.e., those that contain digital objects (DOs), as well as those that only have the DO's metadata, but refer to the location of the resource (Ochoa Agüero et al., 2011). A hybrid model containing both digital objects and metadata is also possible.

The latter is crucial when defining a repository's OD custody policy, as it determines the server's capacity to host it and the system's technical characteristics required for the correct flow of information when queries are made or information is harvested.

Azorín Millaruelo and colleagues (2014) recognize four access statuses to a repository: closed, embargoed, open, and restricted. The first does not allow information to be consulted; it functions to preserve information that should not be in the public domain. A repository with embargoed access is closed, but has a defined date for release.

The open access presents no limits to access the information while, in the case of a restricted level, although there is free access to the sources, the repository owner controls such access through the use of a user account, for example.

The level of access can affect either a repository as a whole or a part of it, its collections, or certain information elements associated with items that, by their nature, are considered sensitive data (a sum reflecting the value of a work of art, the approximate location of an endangered plant species, among others).

Repositories, digital preservation, standards and interoperability

Digital preservation refers to a series of activities that ensure access to digital objects or materials[1] whenever necessary (Hockx-yu, 2006; Torres Vargas, 2008); this implies treating digital objects in such a way that (1) their integrity is always guaranteed regarding any type of damage, loss, or alteration; (2) they are always available to the user who needs them; (3) they can be interpreted and viewed by a user, and (4) the three previous conditions can be conducted in the long term (Hockx-yu, 2006). This implies that digital preservation entails a commitment to the accessibility of digital objects, despite cross-platform migrations, system upgrades, or technological obsolescence. UNESCO ("Noción de preservación digital", n.d.) provides four additional criteria: (5) a permanent collaboration with the producers (creators and distributors of data) is necessary to extend the effective life of the access means; (6) develop a policy of selection of materials to preserve; (7) implement the use of structured metadata that contribute to the preservation process, and (8) work permanently in an economic, timely, global, dynamic, and responsible preservation program. Obviously, these eight conditions must be considered when conceptualizing, creating, and outlining repository access policies.

Although there are institutions with established repositories that have adopted long-lasting approaches and addressed the main obstacles to the preservation and custody of digital objects, as well as an emerging trend worldwide to create or constitute open access repository communities, there is a clear need to further develop strategies that demonstrate their value to the wider community (Confederación de Repositorios de Acceso Abierto, 2013)[2].

The fire tragedy at the National Museum in Rio de Janeiro (2018) is an example of this need. This devastating event caused the destruction of more than 20 million objects considered heritage of humanity, including fossils, mummies, indigenous pieces, incunabula books, among others ("O que se sabe sobre...", 2018). Although

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1. In this case, Hockx-yu (2006) uses digital material; hereafter, we will use digital object, a synonym of the term, following Torres Vargas (2008).

2. To learn more about the current landscape of open access institutional repositories of Spanish public universities and some trends in knowledge socialization see Morcillo López (2016) and Adame et al. (2013).

the National Museum has a website[3], and photographs of some pieces from the collections of biological anthropology, archeology, ethnology, geology, paleontology, and zoology can still be consulted on it, it is very likely that today we not only do not have the physical objects, but we will not be able to recover information regarding many of the objects that the National Museum curated.

This example highlights that a digital preservation strategy combined with the development of an institutional repository are part of a heritage assurance strategy. Likewise, a consolidated digital object preservation strategy brings a variety of benefits to a repository, such as increasing the publications' visibility, providing free unrestricted access to objects in its collection, and thus impacting the intellectual life of an institution, as well as increasing the visibility of queries to its website (Giesecke, 2011; Confederación de Repositorios de Acceso Abierto, 2013; Ganaie et al., 2014).

Two other fundamental concepts related to the practice of preserving digital objects are the terms standard and interoperability. The former is related to the technological platform used in a repository, the metadata with which its objects are structurally and administratively described, the administrative and record publishing workflows, usability and user accessibility, and interoperability with other information systems (Yiotis, 2008; Silva & Tomaél, 2011; Morcillo López, 2016). According to Elings and Waibel (2007), there are four classes of standards: (1) data fields & structure, which are the defined information units, usually called categories or information elements; (2) data content and values, which are the data stored in the categories or information elements; (3) data format, referring to the encoding of the information contained in a file, and, (4) data exchange, which function as the protocols used to share the information of a collection.

In short, standard, in the context of repositories, is related to the consensual use of a software or Internet infrastructure, the implementation of common administrative procedures (deletions, additions, and publication of resources), the adoption of common methods to describe objects (use of specific orthographic rules, terminology reconciliation services or standards such as Cataloging Cultural Objects[4]), the homogenization of the use of international data structure standards, and the consistent and effective access of different user profiles to the repository.

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3. http://www.museunacional.ufrj.br

4. A set of rules for filling out data elements designed specifically for museum documentation specialists, curators of visual resources, archivists, librarians, or anyone who documents cultural objects and their images (Baca et al., 2006).

On the other hand, interoperability, understood as "the way to make visible the exchange of information and cooperative services" (Sayão, 2007, p. 18), can be classified into five types: (1) semantic, related to the adoption of common or mappable tools to represent information; (2) political/human, which considers the consequences of an organization offering information to groups of users; (3) intercommunity interoperability, which considers the basis for the creation of a network of information provision sources; (4) legal, which considers the legal requirements and implications regarding access to information, and (5) international interoperability, when a project has a global scope (Sayão, 2007).

Currently, interoperability is an aspiration and orientation of most repositories in the cultural sector, conditioned by the adoption of standards, a key point to define the degrees of integration of resources on the web and the effectiveness of data exchange between collections (Silva & Tomaél, 2011). Preservation, standardization, and interoperability on the web for the treatment of the "Piedra de Sol" data in Mexicana will be analyzed below.

Mexicana, Mexico's cultural repository, its context, and characterization

Mexicana can be characterized, following the criteria explained in the previous section, as an institutional repository with a clear thematic delimitation, subscribed to the very broad domain of cultural heritage, which stores digital objects (DOs) in its server, but also offers a link that takes the user to the original DO record. It also contains information elements that concentrate open access data, others with restricted access, and others with closed access.

Integrating information generated by institutions with heterogeneous interests and methodologies into a single resource was a challenge for the creation of Mexicana. Therefore, a data model based on the hierarchical classes of the CIDOC-CRM ontology, version 6.2.3 (Aalberg et al., 2017), was proposed for the project. This data model is called Mexico Data Model (MDM) and allows integrating information from all data providers considering five core classes of the CIDOC-CRM ontology hierarchies, namely: date, dimension, place, temporal entity (events and activities), and persistent entity. Additionally, 27 terminology lists were prepared with more than 22 thousand terms that standardize the vocabularies used and index the repository searches (Morales-del-Castillo et al., 2019).

METHODOLOGY

This article reviews the data published for the registry of the digital object and register corresponding to the "Piedra de Sol", published in Mexico's national repository of culture: Mexicana. Based on this, its metadata were identified and

recorded and, additionally, with the aim of making a much richer analysis, it was proposed to directly contrast the source or provider of information from which these data have been retrieved (the INAH Media Library). This methodological decision is justified in light of one this research's main interests, namely: to problematize the challenges of digital preservation in Mexico and with the Mexicana project.

To organize and integrate the data analyzed, I used a table with two columns and as many lines as necessary to record each of the metadata, differentiating the origin of each one of them. The result of this record is shown in an orderly fashion in table 1, shown below.

It should be noted that the search for the item and its data in both repositories involves retrieving multiple records; therefore, it was necessary to filter the results and, through a simple search, select the two correct records. This is because there are many digital objects (images, publications, lectures, audios, among others) that are thematically related to the monolith.

For each of the repositories, two different types of metadata schemas were used, and to guarantee the analysis, I utilized the Metadata Standards Crosswalk of the Getty Institute (Harpring, 2022) to corroborate that the analyzed metadata are semantically corresponding.

Finally, to corroborate some data or resolve concerns that arose during this research, considering the sanitary confinement in the country, I held communications via telephone, messenger, or e-mail with the director of the INAH Media Library, and with Mexicana's operational managers.

MEXICANA'S STANDARDIZATION AND INTEROPERABILITY

The Mexicana Mexican culture repository project, in interaction with other repositories and online databases of museums and decentralized bodies of the Ministry of Culture, is the consequence of a digital preservation program of Mexico's cultural heritage that is very convenient (even though it was not originally intended as such); this, despite the fact that it seems redundant and it is argued that it is neither elegant nor economical to have the same digital objects in the website of a museum, the repository of the decentralized body that manages it, and in the national repository.

The earthquake of September 19, 2017, in which Mexico City was strongly affected, was a case in point. The Conjunto Aristos building, that served as the central office of the National Institute of Anthropology and History, and in which the Media Library server was physically located, had to be vacated (Sebú, 2017).
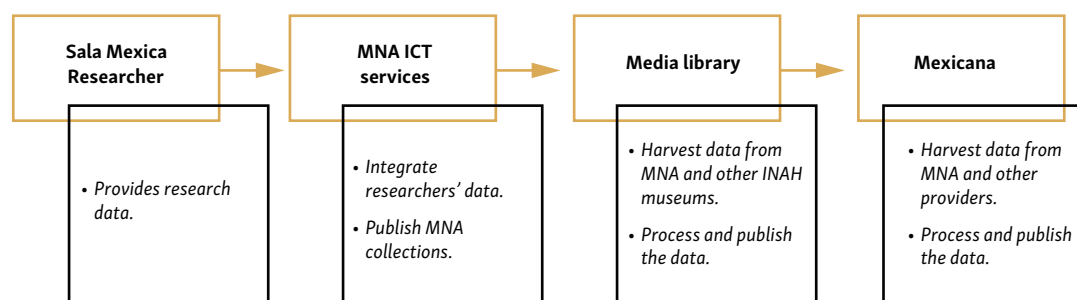
Figure 1. Interoperability. Data flow in the information supply up to Mexicana

Source: Own elaboration.

Fortunately, the Media Library and its information were not compromised for two reasons: first, because days later the INAH institutional repository project responsible had access to the facilities and solved the situation and, second, because from the Media Library they have implemented a systematic physical resource backup program[5].

It should be mentioned that, at that time, Mexicana was only a project under construction and if a hypothetical scenario of the loss of the information of the Media Library project, along with the data of some of its information providers, had materialized, we might have lost years of progress in the digitalization project of Mexico's cultural heritage, and even lost valuable digital information that is now available online.

Currently, the main data of Mexico's cultural sector are preserved in several repositories, with servers in different locations, and constitute very valuable information about the nation's cultural assets; for example: the Piedra de Sol, perhaps the most emblematic Mexican cultural object, widely known throughout the world, has its documentation preserved in the personal archives of researchers at the National Museum of Anthropology (MNA, by its Spanish acronym), at the MNA site, the Mediateca, Mexicana and, possibly, in some other locations. Additionally, in the Media Library and Mexicana, the monolith record is linked to other digital objects such as texts, images, lectures, audiovisual and sound records, among others.

The Piedra de Sol case is a good example of how data flow works in the provision of information between interoperable repository projects. The scientific records of the DB of the researcher responsible for the Sala Mexica of the MNA are collected by MNA's ICT services area of the MNA and published on their website; then, from the Media Library they collect this information and publish it. Finally, Mexicana harvests the information from the Media Library and integrates it into the repository. This flow can be seen schematically in figure 1.

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5. Personal communication with Jimena Escobar Sotomayor, current director of the INAH Media Library, July 2021.

If we focus on the last two steps of this data flow, the ones that concern this article, I dare to affirm that there are two best practice conditions for the cases of the Media Library and Mexicana: first, the adoption of a data structure standard (Metadata Object Description Schema (MODS), for the Media Library, and MDM for Mexicana) and, second, the standardization of the information provided, under specific criteria (orthographic, lexical classes, terminological reconciliation, conceptual grouping of terms, among others) (Agenda Digital de Cultura, 2018)[6]. These two recursive conditions, at each step, improve the data quality with respect to the condition in which this was integrated by the immediate previous provider.

The Media Library has adopted an international standard for bibliographic data structure that is a simplified version of MARC21 (https://www.loc.gov/standards/mods/), which works well for indexing and searching information within the repository. For the case of Mexicana, it is assumed that the decision to implement the MDM, in combination with the standardization and reconciliation of the terminologies of the harvested databases, represents a benefit for the user of the repository to have greater consistency in their searches and greater precision in the retrieval of the requested information. However, considering that the MDM (see section 2) is not exhaustive and functions as a sort of information core, the data provided by the immediate upstream provider are inevitably underrepresented. This can be seen in table 1, which compares the Piedra de Sol data published in Mediateca and Mexicana.

As can be seen in the table below, the Media Library presents 10 descriptive elements of the physical object online (name, description, subject, place of origin, cultural period, date of creation, type of object, collection to which it belongs, description of its physical state and measurements) and five of a legal-administrative nature (institution that holds the physical object, previous location, current location, language, and declaration of rights)[7], while the Piedra de Sol in Mexicana only presents four descriptive elements of the physical object (name, description, type of object and collection to which it belongs), three of legal-administrative nature (institution custodian of the physical object, link to the registry of the information provider, and declaration of rights), but offers two descriptive elements of the digital object that represent the physical object (identifier and format of the digital object)[8].

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6. Personal communication with Jimena Escobar Sotomayor, current director of the INAH Media Library, in July 2021.

7. https://mediateca.inah.gob.mx/islandora_74/islandora/object/objetoprehispanico%3A16419

8. https://mexicana.cultura.gob.mx/es/repositorio/detalle?id=_suri:INAH_OBJETO PREHISPANICO:TransObject:5f3f0fbb7a8a0206312e6484&word=piedra%20de%20 sol&r=0&t=15222

Metadata	Media Library	Mexicana
Physical Object name (PO)	X	X
PO's description	X	X
PO's theme	X	-
PO's place of origin	X	-
PO's cultural period	X	-
PO's creation date	X	-
PO type	X	X
Description of the PO's conservation status	X	-
PO's measurements	X	-
Collection to which the PO belongs	X	X
Institution custodian of the PO	X	X
Current PO's location	X	
Previous PO's location	X	-
Data language	X	-
Declaration of rights	X	X
Direct link to the resource	-	X
PO's identifier	-	X
PO's format	-	X

**Table 1. Comparison between Mediateca and Mexicana
metadata for the Piedra de Sol case**

Source: Own elaboration.

Evidently, for one project the description of the physical object is a priority, while for the other project a balance is sought between the description of the physical object and the digital object. In both cases, emphasis is placed on the rights declarations and conditions of use of the information presented, purely legal aspects, but which are consistent in both cases (four use statements: restricted use, educational and academic use, public domain, and free use). Finally, Mexicana's digital preservation policy and its MDM have a digital object documentation program that the Media Library does not.

The fact that the transfer of data between one repository and the other involves the sifting of information, an undesirable but common feature, and the generation of new data, an absolutely commendable act, is naturally striking. The loss of

information is explained considering what I have already pointed out before, namely that the MDM exclusively retrieves data related to five general classes of the CIDOC-CRM (Morales-del-Castillo et al., 2019), which are not always mappable one-to-one with the data of all Mexicana information providers, which makes the MDM work as an information sieve. About the generation of new information, it is explained because the MDM also does a cataloging of the digital object.

Although it is true that the transfer of information from the Media Library to Mexicana implies a sifting of data, and this has consequences for a digital preservation program, the loss of information is partially compensated by offering the link to the resource in the Media Library.

The following are some of the challenges faced by the Mexicana project, along with a series of final reflections that can be used to extrapolate a specific problem (the transfer of information between the Media Library and Mexicana) to a general scenario in the Mexican context. Likewise, some recommendations are offered to advance in the consolidation of a future digital preservation program for Mexico's cultural assets.

Challenges faced by the Mexicana repository project

This section discusses, based on the definitions and evidence described so far, the challenges faced by the Mexicana project, from the most recent economic policy of public administration in Mexico, the challenge of consolidating a data supply network that allows the repository to grow permanently, to the implicit challenge in the field of data standardization and interoperability (legal, semantic, and intercommunity) among providers in the cultural sector, as well as the implementation of an ideology of permanent collaborative work, and continuous education and updating.

The publication of Mexicana, in September 2018, activated in the country a growing interest in the creation of repositories, the publication of museum collections, the consolidation of existing projects, the generation of synergies and working groups, and triggered the creation of new initiatives with their own personality that, today, rather than being a broad promise, are an incipient and specific reality.

Although the Ministry of Culture cannot speak of overwhelming progress in the publication of information, it should be noted that, despite the change of government in 2018, the changes in the management and middle management of the public administration, and the staff cuts due to the republican austerity program in Mexican institutions, the work planned for the consolidation of Mexicana, in its next phase, has not stopped.

This has led the Digital Agenda for Culture of the Ministry of Culture (ADC-SC, by its Spanish acronym), the directorate in charge of Mexicana, to propose a redefinition of the repository project, opting for the use of free software Tainacan (Lopes Martins et al., 2017) for the creation of digital collections on the Internet. This decision not only implies a change of technological platform, but also of mentality that, in recent years, has been reflected in the migration of collections from proprietary software to free software[9] and, as will be explained below, a change in the dynamics of data provision between Ministry departments, through a network of repositories of the Ministry's departments. In general, Tainacan would be the software chosen for the creation of the data aggregation network of Mexicana's suppliers.

Likewise, in September 2018, which is known as the end of the first stage of Mexicana, according to reports from the ADC-SC (Agencia Digital de Cultura, 2018), the repository integrated more than 700 thousand digital objects provided by the different institutions coordinated by the Ministry, which represent collections of archaeological, historical, artistic, video, and sound collections of Mexico. According to the ADC-SC, one of the future challenges, and perhaps the most important, would be to increase the number of institutional data providers and enter high-quality digital records and objects to the repository (Agenda Digital de Cultura, 2018). This statement assumes that Mexicana, in the last four years, should have increased the number of records it has, and at ADC-SC they have sustained a continuous program of improvement and correction of existing data.

Certainly, a direct review of Mexicana's eight collections, from the 'Explore collections' option, allows to corroborate that the records of the resource have increased by 9,158 items. This can be seen schematically in table 2, which breaks down the collections held by Mexicana and the number of records contained in each of them (data corroborated in November 2022).

As can be seen in the table below, the DO records in the repository have increased by a little over 13% in the last four years. Regardless of whether these advances are many or few, it should be noted that these statistics do not reflect the beginning of a process of revision of the existing items that constitute hard work and a constant improvement of the quality of the resource's data, a process that has been taking place since Mexicana's publication[10].

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9. An outstanding example is the case of the collections of the Museo Nacional de Culturas Populares, collections that are already on this site: http://repositorio.museoculturaspopulares. gob.mx/colecciones/.
10. Personal communication with Alberto Pacheco Pedraza, Mexicana's coordinator, in November 2022.

Colecction	Number of records collected
Sound memory	1100
Visual memory	6396
Outreach	1411
Art	16.516
Books, texts, and documents	7917
History	21.862
Anthropology	14.155
Archeology	9801
TOTAL	79.158

Table 2. Number of records contained in the eight Mexicana collections

Source: Own elaboration.

Regarding the standardization and implementation of data models that have been contrasted in the case study, the comparison between two records of the Piedra de Sol shows the progress of assuming the same line regarding the legal interoperability between systems of the Mexican cultural sector, which finds clear consistencies in the declarations of rights of both repositories, a policy attributable to both the stewardship of the Ministry of Culture and the replication of global trends (Xia & Opperman, 2010; Ganaie, et al., 2014; Adame et al., 2013). Likewise, the two repositories follow a policy line of human interoperability, in which access to information for any user is a priority; this policy is corroborated by having unrestricted access to both resources from any place with Internet access.

The work of data standardization in each of the information harvests is remarkable, i.e., it is clearly beneficial that, in each transfer of data between provider and harvester of information there are spelling revisions, ordering of terms in lexical classes, terminology reconciliation, conceptual grouping of terms, among others, which improves the published data. However, a well-defined program of intercommunity interoperability should consider the consolidation of a network of sources of information provision that contemplates the return of any modification to the data back to the original provider, which does not occur.

In this case, we would see that the Media Library could have access to the descriptive elements of the digital object incorporated in Mexicana, as well as any possible enhancement in the data content of any harvested information element. This simple change in approach would modify the original sequence of steps in the transfer of information from a concatenated linear flow to a new process of providing-harvesting data in a continuous sequence of circular flow. This can be clearly seen in the re-elaboration of figure 1 below (figure 2.).

Figure 2. Circular data flow in the information supply, re-elaboration of figure 1

Source: Own eaboration.

Interoperability between different repositories is beneficial from the point of view of having multiple information backups that are not superfluous in the event of a tragedy (earthquake, flood, fire, among others). Each of these backups constitutes one more point on the web to access information and, naturally, contribute to the heritage's digital preservation. In other words, this corroborates that redundancy, in this case, is a good practice. However, digital preservation of heritage should be thought of as a policy, not as online DO backup actions, committed to ensuring accessibility to DOs, despite migrations between platforms, system upgrades, or technological obsolescence.

All of the above leads me to point out the most important challenge for interoperability between projects in the sector in Mexico: semantic interoperability or between different data models applied to different repositories, as a sieve of information is observed at each step of data harvesting.

As opposed to the policies applied so far, the definition of the data model or standard to be used for the description of DO should be defined by the information providers, right at the origin of the data supply chain. For each information harvester and its information publication policies and user profiles, consideration should be given to mapping to the data model that best suits it. The latter, taking as a reference crosswalk works between standards, such as those published in *Metadata Standards Crosswalk* (Harpring, 2022). This new approach will allow both the return of the information to its generator and minimize the loss of the descriptive richness of each item in each harvest.

Regarding the continuous work and a collaborative approach among the Ministry's departments, it has been proposed that the Mexicana team should expand its lines of work by conducting a comprehensive diagnosis to provide clues on how museums and other organizations coordinated by the Ministry of Culture manage their collections, as well as to identify the technological and human resources they have to do so (Secretaría de Cultura, 2020). This diagnosis is accompanied by a permanent program of seminars on terminology control and knowledge of existing data models for the cultural sector.

This line of work on the management of digital collections and the level of technological maturity in institutions that are custodians of Mexico's heritage, as well as the consolidation of a constant updating program, is very encouraging news. Undoubtedly, the actions derived from these lines of work will contribute significantly to a permanent program of digital preservation of our heritage, beneficial from any point of view.

CONCLUSIONS AND FUTURE RESEARCH LINES

This paper sought to contribute to compare the operation of digital repositories on Mexico's cultural heritage and their interoperability, given the lack of studies of this type, since in Mexico's cultural sector there is a chain of data providers that takes information from the researcher in a room of a national museum to the national repository. It was shown that each of these steps involves a sifting of information. In the discussion, specific emphasis is placed on two notions that are of paramount importance to address this issue: standardization and interoperability (as well as their types and particularities).

As discussed in the findings, a change is taking place in the dynamics of repository work that involves much more the information providers, considering the creation of a working community and continuing education. This provides museum researchers with conceptual tools to understand and decide on the most appropriate international standards for their collections, the homogeneous use of data structures, the consensual use of software or Internet infrastructures, the implementation of the same administrative procedures in collection management, the adoption of common methods for the description of DOs, as well as the design of strategies for standardization and collation of their vocabularies, among other good practices agreed upon among them. It also describes the change to a bottom-up approach in the provision of data which, in turn, has implied a change in the use of proprietary software to freeware (Pacheco Pedraza & Medellín de la Piedra, 2020).

Needless to say, it is beyond the scope of this paper to discuss the implications of digitalizing Mexican cultural heritage, the possible inequalities (or digital divides) for audiences, as well as the political implications related to deciding who and from what positions decide what to consider patrimony and what not to. However, this approach should be considered as a future line of research for the Mexicana project.

Another future line of research is the possibility of constructing a corpus of DOs from various Mexican repositories and subjecting them to more exhaustive or extensive analysis. Thus, it would be possible to compare the variations in the information offered, or to investigate more deeply what the loss or generation of data means for the user when using a record in one or another repository.

One finding in the research for this article was that there is insufficient documentation, accessible online, that accounts for all the decisions made for the publication of the Mexican repository projects mentioned above. Without claiming that this work has not been done, a simple solution to this is to insist on the need to make visible publications describing the theoretical and applied aspects underlying each of the developments and the methodologies that have been adopted. A suitable place to house this documentation could be the repository itself. In this regard, this publication also fulfills an additional objective, namely, to document an ambitious project to document Mexico's digital heritage.

Finally, it has been found that, in the most updated bibliography, concepts such as standard, interoperability, repository, among others, tend to be taken for granted, as if they were sufficiently discussed and had not been redefined in the last 20 years. Therefore, an updated revision is needed and an article in which the dimensions of each of these concepts are problematized and discussed historiographically is desired.

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