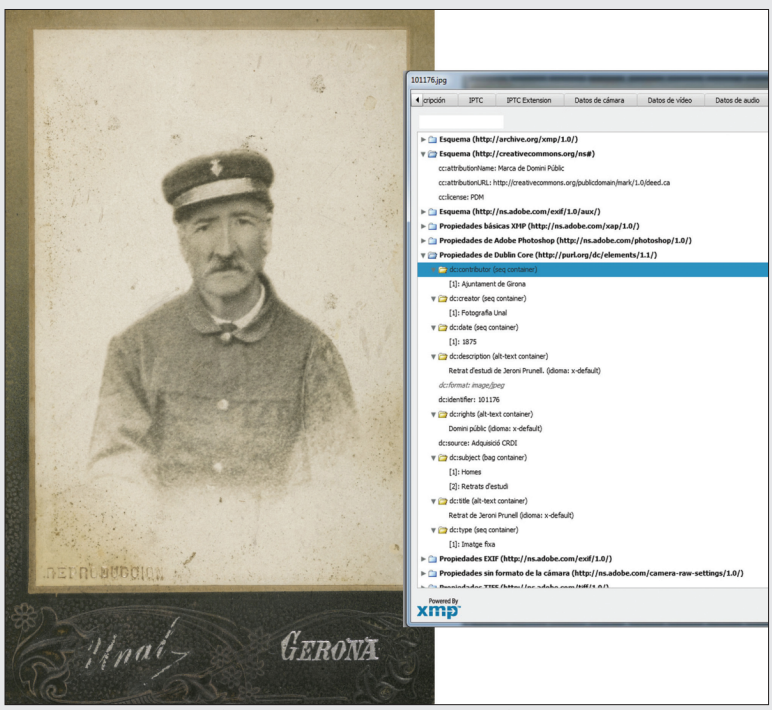
The Definition of a Conceptual Information Map for the Management of the Digital Photographic Archive

David
Iglésias
Franch
Spain

Numerical images talk by themselves, since they contain both the information of every single pixel in the image and the information that allows the interpretation of their totality in different devices: a camera, a screen, or a printer. There is no need for intermediaries apart from the ones that their digital nature imposes: hardware, software, technical specifications, etc. The rules that ensure the communication and the interrelation between all the actors that take part in this scenario are already known by all of them, and therefore, they constitute a solid although changing reality. This technological context that allows to visualize, to edit, or to print images does not seem to have defined boundaries. Any added functionality can be integrated in a digital object, not only without modifying its photographic essence, but also increasing its potential uses. This **functional extendibility** represents a fertile land for many disciplines, such as Archiving and Documentation among others.

The management of information resources has experienced significant change for one main reason: the **dissociation** between the object of custody and the referential information is no longer needed. The physiochemical nature of photography does not accept, as a general rule, a global conception of the informative object, although it may often include a certain level of both referential and management information. The electronic image, on the other hand, cannot be conceived without referential and management information and it cannot easily adapt itself to the traditional practice of separating the information of the image from the one that allows its management.



There are few metadata in the original image. It is the digital version of this image that allows an almost unlimited expansion of these. Furthermore, they are metadata that are normalized and encoded according to different standards.
Ajuntament de Girona. CRDI (Fotografia Unal)

This circumstance leads us to revise specific practices of the archivist profession itself in order to guide us towards the **synchronization** of the object, with its best adaptation in the digital environment as the objective. It is important to have in mind that the object of custody, the digital image, is similar in all the archives, but the final objectives that one pursues that may not be coincident in their totality. It is important to clarify from the very beginning which information we have, and to think about the kind of information we may need in order to carry out our task.

Once this is settled, there is the need to proceed to a deeper analysis in order to know the reality surrounding our working environment. These are the main questions we should be able to answer:

- Which of the information belongs to the digital object and how is it structured?

- Where is this information located?
- Which type of metadata are we talking about: intrinsic or extrinsic?
- Is its capture automatic?
- Which is the level of software dependency?
- Which is the information that we are interested in, and therefore, the one that we want to take part of the digital object?
- Which are the functionalities associated to the digital object?

To answer these questions and decide which informative environment that we want to establish, it is convenient to know what our images are like and to be clear about the kind of reality that we want to build. In conclusion, we need to design our archive starting from a solid basis, on the margins of any temporary circumstance and without dependencies on specific technologies. The first step for the creation of an information conceptual map is one's own first reality analyses – an **information conceptual map** established as the main element and the base element for the design of the digital archive. It is from this map that we may be able to determine in a consistent way the conception of the digital object that we aspire to manage and, depending on the resources, how we will do it. For the configuration of this map we will need to focus on the following aspects:

- The information blocks that will take part in our map;
- The existing standard metadata containers;
- The structuring and combination of these metadata, keeping the aspects related to interoperability and codification in mind;
- The assigned responsibilities and functions that need to be put in relation to the blocks of metadata and that have to determine the software needs.

Information Blocks

The creation of the information map depends on the amount of data that we need in order to be able to assume the functions derived from the inherent responsibilities of custody and access. For a start, we have the image data and the technical data that allow us their representation as well as their operability. To these, we will add the different blocks of data that we shall determine according to our interests and needs and specifically to the blocks referring to: capture information, author information, archive information, administrative information, historical information, environment information, and preservation information. Let us analyse straightaway the main information blocks.

Primary Information. The image's basic information is the information at pixel level, the smallest unit into which one can divide the numerical image. The digital encoding is produced in a process subsequent to the capture in which the voltage is sent to an analogue-digital encoder and the pixel's value is assigned. This value is the one that determines the tone of the image and, depending on the phase of the processing, the colour. The assignment to this value is the key for the subsequent image representation, since a 16-bit encoding, for instance, offers a higher

precision and above all more intervention options in the processing than an 8-bit encoding. Since we are talking about millions of pixels, the code is large and hardly comprehensible as a whole. That is why a set of data that make it comprehensible for machines is needed; these are the metadata that set up the second block.

Representation Information. This set of metadata determines the image's technical characteristics and allows its representation in different environments. The main metadata are the ones that give us information about the condition of the image in the digital file, its encoding, and its configuration, mainly the spatial resolution and the bit resolution. The metadata that allow the location of the different pixel values in the map of bits, those recording the file size, and those that refer to colour management, a fundamental and complex aspect in the representation of the photographic image, are also indispensable. A lot of these metadata are determined by the selection of the file format, since this establishes and delimits, in large part, the technical image characteristics. They are automatically captured and belong to the file header.

Capture Information. This information allows us, above all, to know the capture conditions. It is mainly about the metadata referring to the capture's technical conditions as well as its processing, since, with the exception of RAW files, the processing is automatic according to the camera configuration. The basic capture data are the exposure time, the F-number, the ISO speed, the colour temperature, and the use of flash. Among the basic processing data we find the white balance, the contrast, the saturation, and the sharpness. The information about the date and time of the capture, of great value for the archive, are part of this block, too. Additionally, and depending on the machines, we will count on the geographical information that integrated GPS systems provide. In the case of RAW formats, a large part of this information is preserved in an attached file, which allows the preservation of the integrity of the capture's data without any type of processing. All these are metadata of automatic capture.

Author's Descriptive Information. These metadata provide information about the author, but at the same time, they may include information about the scene provided by the author himself. Although some of these metadata may be coincident with the next block, initially, one should consider them separately for the existing differences in semantic nuance and formal aspects. When referring to the author, the main metadata are the name, the profession, the contact address, etc. When referring to the image's description provided by the author we should mainly consider the title, the summary, the place and the keywords, the latter of very little value for the final archival description. These are metadata of manual insertion.

Archive Descriptive Information. This includes information from other blocks, such as the ones referring to image contents (author, title, and summary) and to the description of the object (format, resolution, etc.), although in some cases one may need to adapt their values to achieve their standardization and to include the thematic identifiers and descriptors. But besides these data, there is a set of information that is absolutely relevant. This is the case of the management of the different existing registers that should allow the identification of the digital object, as well as the original image (when referring to a digitization), or related images. One

should also consider fundamental the different relevant dates for access and management (such as the date of capture and the original image processing date). But the main added value in the description process comes from the production's context information that is fixed by specific metadata such as those describing the fond or the collection, or those derived from a functional classification. Finally, we should consider the metadata corresponding to the description of the physical object, since in many cases it will refer to a digitization. These can be so large and we should mainly consider the following ones: the carrier, the format, the photographic process, the colour and the condition of preservation. These are metadata of manual insertion.

Administrative Information. This block may include different types of information and basically the ones corresponding to the entry, the control of the cataloguing, the access, and the use of the images. This information can be specified by the following metadata: the entry's date, the type of entry, the origin, the cataloguing date, the cataloguer's name, the access restrictions or the access conditions, among others. But the main metadata are the ones that regulate intellectual property, such as: copyright, instructions for legal use, date of public domain, license use, etc. These are metadata of manual insertion.

Historic Information. It refers to the compilation of information about the actions that have been taken in the image processing and that are different from the ones related to the original processing. It refers to the registering of the changes in relation to a fully processed original image (the capture's image), from which one creates a derived file for the archive. Among the most common, we may find the actions referring to file format conversion, cut, editing, copy, masking, resolution changes, etc. These can be metadata of automatic capture.

Environment Information. It is important to gather the information about the devices and the software that have been used, since the capture's final result is conditioned by their characteristics. The main metadata are the ones referred to the identification of the manufacturers of the camera, the scanner and the lens, and of the specific devices, including the serial numbers. The software used for the image's capture and editing should also be considered, specifying also the version. In the case of digitization, we can also include in this block all those metadata that derive from the analysis tests made with respect to the devices and the software that have been used in order to optimize their efficiency. They are mainly MTF and OECF. The metadata derived from efficiency tests are of manual insertion, whereas the rest can be of automatic capture.

Preservation Information. We can easily understand that the majority of the metadata developed in the different blocks are of interest for preservation, especially considering the indications of PREMIS that the functionality of the metadata in its dictionary respond to the need of preserving the viability, the understanding, the reading, the authenticity, and the identity of the files. But we can also consider some additional metadata, such as those referring to storage support, localization in the repository, inhibitors (e.g. encryption), numeric summaries of the file, or the bit chain (in the formats in which this is possible) and the applied algorithms to obtain these.

We should say that these are purely illustrative blocks, which are intended for digital archive management from a heritage perspective. Despite this, they are representative enough of the information that one should take into account when creating our conceptual map. If we turn our attention to other professional fields, such as the press or the editing sector, the constitution of these blocks would partially differ and in some cases one should include additional metadata blocks.

Metadata grouped according to the information blocks. This diagram constitutes the base of the conceptual map, to which we should associate the different containers and the standard file formats.

Standard Metadata Containers

The identification of the blocks, the development of the metadata for each block and the selection of these on the basis of the functions that one wants to assume allow the drawing of the base of the map. Despite this, in order to work with a map that may become operational, one should structure this information according to the existing standard metadata containers and locate them according to the hierarchical structures of the image files we are working on and according to the preferred graphic formats. The existence of different metadata standards and the different rules for each one of them referring to the storage, the organization, and the encoding within the file are questions that we should take into account when developing a management system, keeping in mind the influence that the decisions we make about these topics may have on the final constitution of the digital object.

The synchronization we referred to at the beginning of this text offers some management possibilities that we should not underestimate, and which allow us to work in a more optimized way according to the current technological surroundings. Despite this, in order for these possibilities to become real, we cannot limit ourselves to the tools that the market offers, that is, to be limited by the software that we use. We should know, first, what our responsibility is in the image collection management and which standardization work has been carried out regarding the digital image specifically, and the electronic documentation in general, so that we may later identify those standard containers that offer fully developed lists of metadata, with compatible structures and universal codifications.

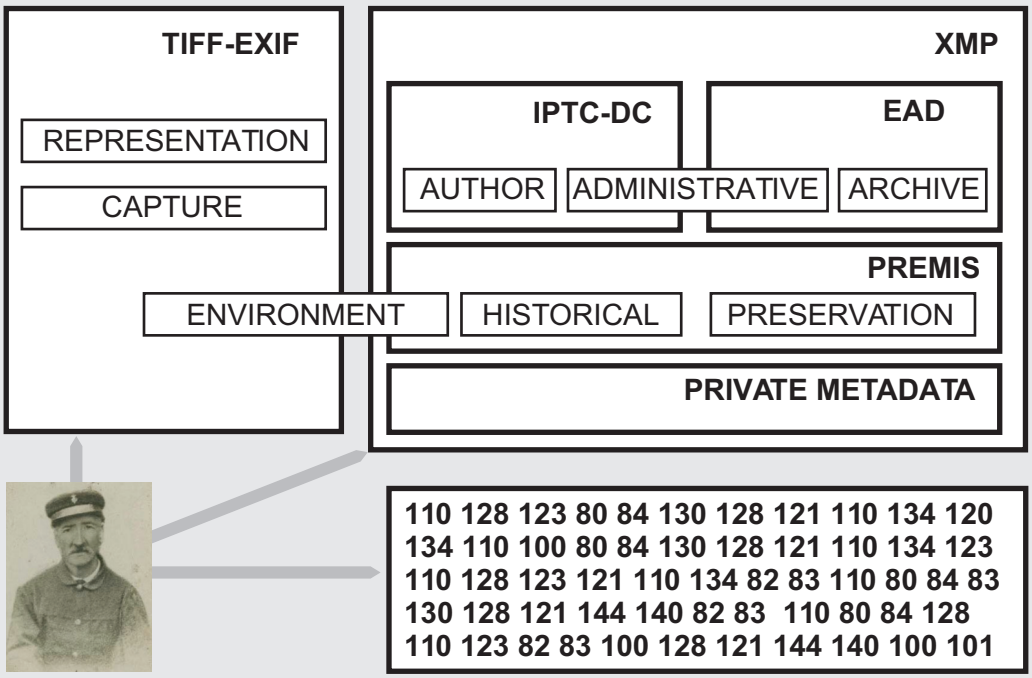
For a start, we can differentiate those standards that are specific to, but not exclusively of the still image, from those of a more general nature. In the first group we find EXIF-TIF, IPTC, and XMP; whereas in the second one we find EAD, DC, and PREMIS (among others). The functionalities of the archives make the consideration of this second group of metadata indispensable, and it becomes advisable to invest the effort to integrate them within the digital object. Despite this, when managing the digital image we can prioritize the specific standards, since they are included in the image file and, therefore, they can be used by the software. We could also include in this group the Photoshop (PSIRs) metadata, for the generalization of their use (although they are a resource of a proprietary format). The combination of the specific standards fulfils a good part of the needs related to access and use, although in the heritage field we cannot omit the second group. The integration of both of these groups in a management system is a future challenge that should allow the configuration of a photographic archive that has to be efficient in the assigned functions, versatile with respect to technological adaptation, and sustainable through compliance to standards.

EXIF (Exchangeable Image File Format) is a standard from the JEITA (Japan Electronics and Information Technology Industries Association) and the CIPA (Camera and Imaging Products Association) developed out of the need to be able to exchange images created by digital cameras with other devices. This need led to the creation of the DCF (Design Rule for Camera File System) specification, which establishes the rules for the recording, the reading, and the support of image files and of other related files, and which defines a subset of EXIF where some of the properties are optional in EXIF but compulsory in DCF. EXIF, in fact, is a graphic format that presents a structure in accordance with the JPEG format for compressed images and in accordance with the TIFF format for the images without compression. In both cases, EXIF describes a set of TIFF labels, according to the format described in version 6.0, and for camera-related information not considered in TIFF, it includes metadata in a directory of its own, which is separate from the TIFF metadata directory as well as from the GPS metadata directory. In correspondence with the information blocks described in this text, EXIF represents in an encoded way the representation blocks (TIFF metadata), the capture's (own metadata directory and GPS directory), and the environment's (it includes the OECF and the SFR values). It also includes two additional pieces of metadata for rights management: Artist and Copyright, of very little significance when combined with other standards.

IPTC – IIM (International Press Telecommunication Council – Information Interchange Model) is a wrapper format created by a consortium of news agencies for the transmission of news containing textual and image information. The IPTC headlines, which were adopted and included by Adobe in Photoshop using the Image Resource Block technology, were created from the IIM. Afterwards this technology was substituted by the XMP and two new schemes were created: first the IPTC Core and then the IPTC Extension (both XMP exclusive). The IPTC Core respects the IIM structure and it inherits many of its metadata, replacing the original IIM headlines. The IPTC scheme associates the metadata with the following schemes: DC (Dublin Core), Photoshop, Adobe Rights Management, and IPTC IIM. Actually, the relation with the IPTC IIM scheme makes it include the majority of the IIM original metadata. We have to bear in mind that IIM metadata are generated in the journalistic field and that most of them have no value for the archive. The IPTC Extension is the result of the photography professionals' requirements for including additional metadata in the initial scheme, since the need appears for the management of specific information coming from the business flow. It has a lower level of compatibility than the Core, though it works with more specialized data. In the inherited field, the main metadata of interest are those of the IPTC Core, many of which are assimilated to a DC scheme, as in the case of the author, the description, or the title. These mainly correspond to the information blocks that are about author's descriptive data and administrative data, both defined in this text. Some Extension metadata can be of interest anyway since they refer to the image content: identification of people, of places, or description of events, whereas the other ones are associated with other professional sectors.

XMP (Adobe's Extensible Metadata Platform). It is a standard for the creation, processing and exchanging of metadata. It offers a labelling technology that allows the creation of new metadata and their insertion in the same files. It refers to XML data, stored using a subset of the W3C Resource Description Framework (RDF). This becomes especially interesting for the computer industry, since the software and the devices can include self-information in the same files. It is also important for the cultural sector, since it allows the possibility of including self and appropriately encoded metadata in the XMP containers. In the case of the archives, it presupposes the possibility to consider the integration of EAD metadata in such a way that these will become intrinsic metadata for the TIFF, JPEG, JPEG2000, DNG, PSD and PNG graphic formats. In the other formats, an independent metadata file is created. The XMP defines four blocks of main metadata, the DC and three of its own, plus the specialized blocks: Adobe PDF, Photoshop, Camera Raw and Exif. The inclusion of the DC in the main properties turns it into a technology of great utility for communication between the different platforms. Referring to the XMP exclusive metadata, we are mainly interested in the first three blocks. The first one contains the basic descriptive data of the digital resource, such as the date of creation, or the date of modification, or the date of the modification of the metadata. The second block is formed by the management of rights data, with some interesting additional metadata as the one that refers to a management certificate or the one that refers to a declaration of property and the right for the resource's use. The third one is formed by data related to the identification, composition and history, which allow the monitoring of the transformations experienced by a specific resource. In conclusion, we can say that the XMP's main expected metadata partially correspond to the blocks

of author data, file data, administrative and historic of the blocks defined in this text. From this point of view, the contribution of the XMP as a standard would not be interesting enough for an archive, since it refers to metadata that conform to other standards. The XMP's main contribution is its extensibility and the possibility to encode these additional metadata on the basis of standards, and even metadata created by the archive itself that do not have to necessarily take part in any encoded standard.



Information blocks of the conceptual map in relation to the containers and schemes of standard metadata according to their inclusion in the JPEG and TIFF graphic formats.

Structuring and interoperability

Due to their diversity, it becomes logically complicated to organize and store the metadata standards, since we can find different hierarchical structures among them.

To start, we have to bear in mind that the electronic files may contain different formats and at the same time these may contain different bit chains, with their own metadata. Besides, these formats foresee the integration of different metadata containers that in turn can converge in any of their objectives, a fact that may result in the repetition of some metadata in different containers.

The intersection between file formats and metadata containers causes complex and confusing relationships, with metadata that are grouped and stored in different ways according to the formats. In this text we will only focus on TIFF and JPEG formats, for the generalization of their use, and on the EXIF, IPTC and XMP containers, all of them seen in the aforementioned formats and as the ones having an outstanding presence in the photographic industry. Other standards

such as the EAD or the DC would become integrated within the XMP package, and therefore, would not complicate the structuring, the organizing, nor the storing of the metadata within the files. To start from this scenario simplifies the casuistry derived from the relationships of these items at the same time that it brings us closer to the most common archival context.

The analysis of the relationship between metadata at a structural level when referring to TIFF and JPEG formats reveals the complexity of a global fitting. The TIFF format, apart from its own metadata, has 5 more subsidiary directories, those corresponding to the XMP, IPTC, PSIRs, EXIF and GPS metadata. The JPEG format organizes the metadata in the different section marks from which we differentiate the ones corresponding to the TIFF-EXIF, to the XMP and to the PSIRs (which includes the IPTC). So, unlike the TIFF, the JPEG does not contain a specific section for the IPTC, but rather takes part in those of the PSIRs; whereas in TIFF, the IPTC metadata can be duplicated – the native metadata, and those in PSIR. The TIFF-EXIF section of the JPEG points to a TIFF directory that includes the TIFF metadata and a label that points to the EXIF metadata. Neither of the two graphic formats considers the XMP block inside the PSIR, since the XMP has its own space. In the exceptional case that the XMP package exceeds the 64 Kb expected by the JPEG, we may consider the possibility of splitting this package into two blocks: the standard XMP and one extension. We have seen that both in the case of the TIFF and of the JPEG, they include, besides the aforementioned containers, also the PSIR (Photoshop Image Resources) container. It refers to a native resource of the PSD format that is present in these two formats and it also includes resources of metadata and, more specifically, the XMP, TIFF-EXIF, and IPTC standards, although the specific contents for the PSIRs are different according to the format. When we refer to the possibility of including EXIF data in the XMP it becomes especially useful for these formats that do not include these metadata in their structure. This is not the case of the TIFF nor the JPEG, in which it is not recommended to include the EXIF metadata in the XMP, but rather is advisable to keep the native EXIF metadata. In all the file formats, the native metadata (that is the metadata foreseen in the format structure) take preference over the XMP. As a conclusion for this explanation of the relationship between formats and containers, we can say that TIFF and JPEG integrate the same type of metadata, but they are stored in slightly different ways.

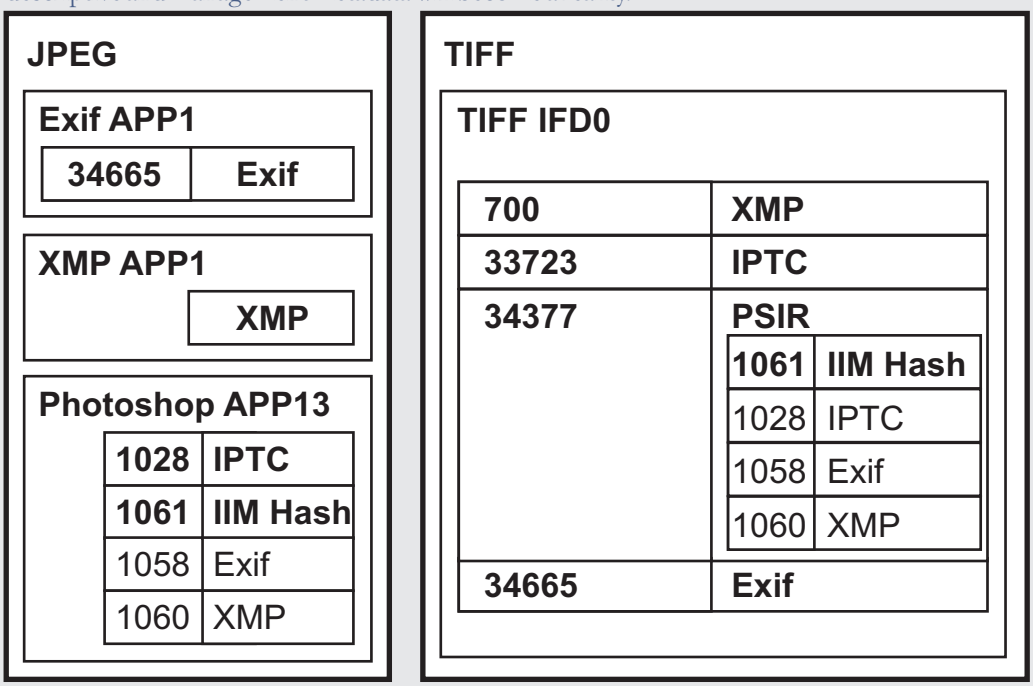
One should be aware of the fact that the combination of metadata containers is complex, since the difficulty in their management mainly derives from the correct assignment of the metadata values, the changes in the different standards in relation to the software evolution, and the encoding requirements. In this sense, the software behaviour becomes essential to retain the metadata's coherence, compatibility and consistency. The difficulty in combining the metadata standards is then mainly due to issues of file structure, data storage, and the partial repetition of the containers; to the way to access these metadata; and to the problems caused by different software programs that do not always operate in favour of metadata consistency and compatibility.

The interoperability problems caused by the repetition of metadata in different containers become less alarming if we take into account the study made by the Metadata Working Group in

2010. This study reveals that there only exist four metadata that coincide in the EXIF, IPTC, and XMP dominant standards. These are:

- Copyright: Exif Copyright – IPTC CopyrightNotice – XMP (dc:rights).
- Description: ImageDescription – IPTC Caption – XMP (dc: description).
- Original Date: Exif DateTimeOriginal – IPTC DateCreated – XMP (photoshop: DateCreated).
- Author: Exif Artist – IPTC By-line – XMP (dc: creator).

The fact of having identified the coincident metadata and, in general, the existence of a working group encouraged and supported by the photographic industry (Microsoft, Apple, Adobe, Canon, Nokia, and Sony) working toward a definitive solution for the integration of the different metadata types, make us imagine a future scenario in which the integration of technical, descriptive and management metadata will become a reality.



Structuring and organization of the metadata containers in JPEG and TIFF formats. Graphics published in: Guidelines for Handling Image Metadata. Metadata Working Group, 2010.

Metadata in relation to the workflow

We have seen that the metadata standards were created because different economic and professional sectors needed to fulfil specific objectives. The photographic industry, through the CIPA and the JEITA, developed EXIF in order to exchange images created by digital cameras with other devices. The news agencies, through their international consortium, developed the IIM for the transmission of the news both through text and images. The information and

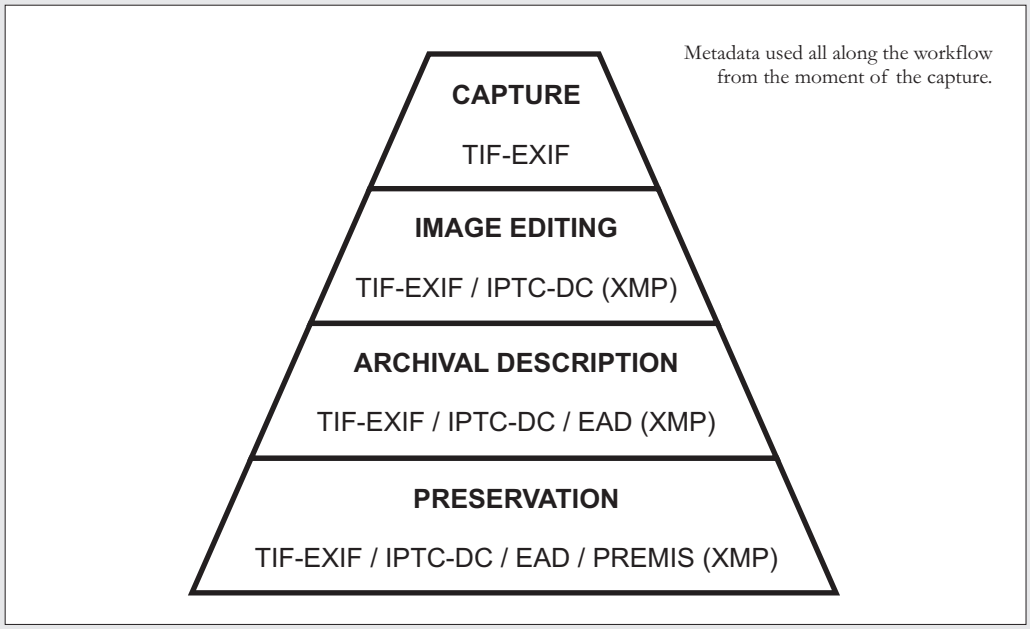
documentation sector, through an interdisciplinary work, developed the DC for the basic description of information resources. The archives sector developed the EAD to provide a solution for the encoded archivist description. The industry of software editing, represented by Adobe, developed XMP for the creation, processing and exchange of metadata. The documentation sector, mainly libraries, developed the PREMIS dictionary for the preservation of the digital object. We could add other standards that were not mentioned in this text because they are considered less relevant for the archival sector. It is important to bear in mind the respective objectives of these standards in order to put them in relation to the different functions that derive from the workflow that begins with the capture and ends in the archive. All along this process the image transformations that take place are not only on the contents, but on the information that comes with them, the metadata, since the final objective is to achieve the creation of a digital object that is accessible and sustainable.

A series of metadata are produced when capturing; although these metadata will change according to the graphic format, they will always allow the interpretation of the image's contents in a more or less restricted way, from the maximum compatibility that JPEG and TIFF offer to the limitation of RAW's proprietary software. Apart from the native metadata of each format, a series of metadata from the capture are also created in an automated way, the EXIF metadata, that become part of the same file in the TIFF and JPEG and are normally kept as attached files in other formats.

From here, the work of image editing starts, which will be different according to its producer, whether it is a photographer, a newspaper, a publishing company, an individual, etc. In all the cases it will finish with an image more or less transformed and with additional metadata introduced by the editing software (for example, Photoshop). So it refers to technical metadata that can be captured in EXIF and permits a technical assessment of the file, analyses of its format and its validity, and even the determination of its authenticity. This stage is not limited to the contribution of the technical metadata, but may also involve the inclusion of descriptive metadata for the identification of the author and of the image's basic contents, and also for rights management. It refers to metadata that are kept in an exhaustive way by the IPTC, and more specifically by the IPTC Core, if we work with the XMP platform. From here, if we require the insertion of the metadata in the same file we need to work with XMP, since the native containers considerably limit the extensibility of the metadata. The other option, today still the most frequently chosen in the archives, is to make use of databases, with referential information of the object.

Once entry is admitted and upon completion of the ingestion of the images in the system, the work on the archivist description takes place, paying special attention to the producer context information and to the information that have to give support to the administrative work. It is at this moment that the EAD is introduced and begins to coexist with the EXIF, the IPTC, and occasionally with the XMP. The responsibilities with respect to preservation deserve to be considered apart, since the necessary information will depend on the planned strategies, which may hardly be limited to the archive field. The PREMIS dictionary gives us an idea of the

exhaustiveness of such information and of the need to articulate a plan set within an institution or an enterprise with the involvement of technicians from the different fields.



Lastly, we should consider the functions that derive from the access and diffusion of the images of the archive, which may mostly depend on the environment in which it is produced (the Web, an intranet, a publication, etc.) and on the options presented (access to a final image, access to a referential image, print option, purchase option, etc.). In this phase, it is highly recommendable, and in some cases indispensable, to consider a standard such as the DC. Therefore, if lucky, we will count on the EXIF, DC, EAD, XMP and IPTC standards. Despite this, we should bear in mind that we cannot be exhaustive in the diffusion of these metadata. On the one hand we are dealing with personal data that cannot be made public, as in the case of some IPTC metadata, or with administration data that have to be limited to the archive use, as in the case of some EAD metadata. Besides, we should consider the convenience of being more or less exhaustive in specific environments, as in the case of shared portals, where a description of the DC basic elements may be not only enough but often more convenient. In all the cases it is important to ensure that the software that is taking part in the different phases and processes has the capacity to duly keep and store the existing metadata on the margins of the modifications and changes that may be produced within the digital object.

Conclusions

The conceptual map for the management of the digital image has to provide an answer to the two main questions formulated at the beginning of this text about the information that we have and

the information that we need to carry out our task. Its conception depends on a job that every archive can elaborate in an individualized way and that has to take into account the following phases:

- To identify the archive's informative needs and to elaborate a list of properly structured metadata;
- To value and consider the existing metadata blocks, no matter if they are specific to graphic formats (native metadata) or transversal to different formats (the containers), or in dictionary form or schemes;
- To select those standards that better respond to our needs and to put them in relation to the agreed initial structure;
- To determine the specific functions of the different phases of the workflow and to put them in relation to the metadata blocks.

The conceptual map should be conceived to be operational, and therefore one will have to answer all those specific questions that will allow a decision on the way of working and on the software needed for the execution of our job. It is indispensable to know which metadata take part in the digital object and the way they are structured, a fact that requires a good knowledge of the formats on which we are working on and software that allows us to value the reality of our objects. Once these metadata are known and once we know how they are structured, we need to see where they are located: in the same file, in attached files, in databases or, as usual, shared among files and databases. We should also distinguish if they come from an automatic capture, and in which moment this capture takes place, or if they are of manual insertion; if so, we should automate everything possible for the different documentary processes to be feasible. We should still determine if there is software dependency, something that determines our adaptation in the constant evolution of the technology. Lastly, we should foresee which functionalities will be associated to the original object and, therefore, be conscious of whether we have the needed information to carry them out. Depending on the results of this analysis, we will be able to develop or to acquire the software that will allow us to carry out the functions that we have been assigned so that the conceptual map can be operational on the basis of the informative and technological reality of our environment.

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