BIBFRAME AV Assessment: Technical, Structural, and Preservation Metadata

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Introduction

This report presents the findings of a study conducted by AVPreserve on behalf of the Library of Congress to evaluate the existing state of technical, structural, and preservation metadata for audiovisual resources in the bibliographic environment in light of existing standards for audiovisual metadata, and to make recommendations about how BIBFRAME can support the expression of such information.

Audiovisual resources provide important use cases for testing the scope and breadth of BIBFRAME as it is being developed. First, simply the category of "audiovisual" represents a wide array of media types, from traditional celluloid film to digital video files; the complexity of each of these individual categories of media offers a rich test bed with which to examine BIBFRAME. Additionally, given that most (if not all) physical audiovisual resources will need to be migrated to the file-based domain for preservation and access purposes within the next few years (if they have not been already), it is urgent that a clear plan for technical, structural, and preservation description of both physical and digital resources be articulated for the library community. It is our hope that this report simplifies and provides clarity on a complex set of questions for a complex set of resources by offering concrete suggestions for the handling of audiovisual resources within BIBFRAME.

This report recommends an informed scope for BIBFRAME's role in audiovisual description, particularly when viewed next to other existing namespaces that serve complimentary, but potentially overlapping, functions. It is structured hierarchically according to three specific areas of inquiry:

1. To provide a recommendation on the relationship between BIBFRAME and PREMIS in order to help guide implementers in their decision-making process when determining the role each should play. This is particularly important given that there may be similar semantic classes within each (e.g., BIFRAME Event vs. PREMIS Event), and that they both offer mechanisms to describe the technical attributes of resources.

2. By going one level deeper into the structure of audiovisual resources themselves, to investigate the applicability of structural technical descriptions within the bibliographic context and to recommend an appropriate scope for structural expression within BIBFRAME versus other namespaces.

3. After having articulated a proposed scope of BIBFRAME's role with regard to preservation, structural, and technical metadata, to provide recommendations on specific technical attributes of audiovisual resources that should be supported for bibliographic description within a linked data framework, and suggest ways that these might be accommodated by BIBFRAME.

This study follows on our May 2014 report titled, "BIBFRAME AV Modeling Study: Defining a Flexible Model for Description of Audiovisual Resources,"[1] also commissioned by the Library of Congress, which explored and provided high-level recommendations on a flexible data model for audiovisual resources. Where applicable, a summary of the key recommendations of that report is provided herein.

[1] Kara Van Malssen (AVPreserve), "BIBFRAME AV Modeling Study: Defining a Flexible Model for Description of Audiovisual Resources," Library of Congress, May 15, 2014. Available from http://www.loc.gov/bibframe/pdf/bibframe-avmodelingstudy-may15-2014.pdf

Scope of Study

The scope of BIBFRAME, as defined in the FAQ, is to be "the foundation for the future of bibliographic description that happens on the web and in the networked world. It is designed to integrate with and engage in the wider information community and still serve the very specific needs of libraries."[2] This definition raises the question of the scope of the concept of *bibliographic description*, the primary function of library cataloging, which is quite broad. The International Federation of Library Associations and Institutions (IFLA) final report on Functional Requirements for Bibliographic Records (FRBR) describes the complex uses and scope of bibliographic records: "For the purposes of the study, the users of bibliographic records are seen to encompass a broad spectrum, including not only library clients and staff, but also publishers, distributors, retailers, and the providers and users of information services outside traditional library settings." That report, "takes into account the wide range of applications in which bibliographic records are used: in the context of purchasing or acquisitions, cataloguing, inventory management, circulation and interlibrary loan, and preservation, as well as for reference and information retrieval."[3] Thus, on one hand, since library cataloging is in large part intended to support discovery of and access to library materials by patrons and reference staff, bibliographic records are often created with these use cases in mind. On the other hand, libraries have internal curation and collection management needs that go well beyond patron discovery and access, and uses of the library catalog typically extend to the documentation of these aspects of a resource.

The January 2015 report, "Common Ground: Exploring Compatibilities Between the Linked Data Models of the Library of Congress and OCLC," by Carol Jean Godby (OCLC) and Ray Denenberg (Library of Congress)[4], provides specific insight into BIBFRAME's scope, particularly when compared to the approach that OCLC had taken to utilize Schema.org and the BiblioGraph.net extension for library materials described in WorldCat. The authors note that, "The vocabulary defined in Schema.org and BiblioGraph aims to be broadly understandable to the information-seeking public and may not include many of the details defined in BIBFRAME, which aims more to address the needs of long-term curation by libraries and other cultural heritage institutions,"[5] and therefore, "BIBFRAME descriptions can also be more detailed because they include the specialized vocabulary required for professional curation."[6]

Indeed, existing bibliographic structure standards such as MARC and content standards such as RDA include a large number of elements that either implicitly or explicitly serve collection management, curation, and stewardship use cases more than those for discovery. In some scenarios, certain fields and data values may not even be exposed to patrons.

Therefore, the scope of this study necessarily factors in the function of bibliographic description as a complex tool for library stewardship, encompassing search, discovery, and to some degree, curation and collection management. Because an important goal of the study is to ensure that existing data

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[2] http://www.loc.gov/bibframe/faqs/

[3] IFLA Study Group on the Functional Requirements for Bibliographic Records, "Functional Requirements for Bibliographic Records," International Federation of Library Associations and Institutions, September 1997, amended 2009. Available from http://www.ifla.org/files/assets/cataloguing/frbr/frbr.pdf, pp. 3-4

[4] Carol Jean Godby and Ray Denenberg, "Common Ground: Exploring Compatibilities Between the Linked Data Models of the Library of Congress and OCLC," Library of Congress and OCLC, January 2015. Available from http://www.oclc.org/content/dam/research/publications/2015/oclcresearch-loc-linked-data-2015.pdf

[5] Ibid, p. 8

[6] Ibid, p. 10

found in MARC records can be migrated to RDF properties, either defined by BIBFRAME or another recommended external namespace, BIBFRAME should have a documented approach for treating each MARC field and sub-field, which includes those that may have more of a curation than an access function. Considering these factors, a key question becomes: how granular should BIBFRAME be in its support of the full spectrum of bibliographic data management requirements for audiovisual resources? When should other namespaces, which are more explicitly designed for collection management, be used? What are the dividing lines between these?

It is challenging to draw a definitive line between metadata that is specific to discovery and use, and that which serves collection management and preservation functions. Many attributes serve multiple uses. For example, the bitrate (i.e., for time-based resources, the amount of data delivered per second over time) of a moving image or sound file tells users different things. For a researcher who is trying to locate footage to use in a new documentary film, the bitrate is an indicator of the file's resolution, and will help that user determine whether or not this file will be of suitable quality to bring to her producer. For a librarian who is working on an online exhibition of special collections resources, the bitrate indicates whether that resource is of suitable quality for web streaming. If the librarian has multiple instantiations of the same content item, the bitrate could be one way to determine which is the streaming proxy, and which is a preservation master. While we propose that bibliographic description viewed through the lens of BIBFRAME should incorporate some aspects of collection management and stewardship (especially for physical resources) to support these various use cases, there are existing purpose-specific ontologies that more readily support the detailed and ongoing activities of digital preservation (e.g., PREMIS), and which also have an important role to play.

By examining the technical structure and uses of audiovisual media, this report proposes a distinction between the multivalent role of bibliographic description in support of collection management, search, discovery, and access in BIBFRAME and the role of a vocabulary such as PREMIS and other industry-specific audiovisual vocabularies for ongoing stewardship. We offer propositions that will enable the implementation of these in concert with one another. Additionally, the recommendations in this report were developed with the intention of providing librarians with a sufficient level of detail to express the technical attributes of audiovisual resources in order to support discovery, use, and curation scenarios, both for legacy data contained in MARC records, as well as for new data to be created utilizing BIBFRAME. In order to provide a comprehensive set of recommendations toward these goals, this study looks within as well as outside of MARC and library content standards to identify technical attributes that to date have not been addressed by the library community. However, we do recognize that the level of detail that can be expressed about audiovisual resources and that is, in fact, in use within communities such as broadcasters or sound archives, can be quite deep. Therefore, as a rule of thumb, the guidelines we are using to determine the appropriate level of detail include the level of granularity recommended by content standards and available within MARC, as well as an understanding that most bibliographic data is created by humans (while also acknowledging that in the future metadata for digital materials can and will be created by machines).

Assumptions & Foundations

This study was carried out using the BIBFRAME 1.0 vocabulary as it existed in February 2015, an experimental vocabulary that did not yet accommodate AV material except for a few token properties. The Library of Congress (LC) has plans to revise the BIBFRAME vocabulary and model in early 2016

taking into account studies such as the this one and our 2014 BIBFRAME AV Modeling Study. We will use the term “BIBFRAME 1.0” when referring specifically to the state of the vocabulary at the time of writing.

This study assumes a conceptual model of audiovisual resources that will be central to the analysis and recommendations throughout. In our previous AV modeling study, we recommended a content creation domain model and a content description data model that articulate the affixation of information onto a recording medium as the definition of an Instance in the BIBFRAME model. For AV resources we note that the information affixed can stem from that of a creative work or simply of the documentation of an event that occurs in time and space, which may or may not have a relation to a work.[7]

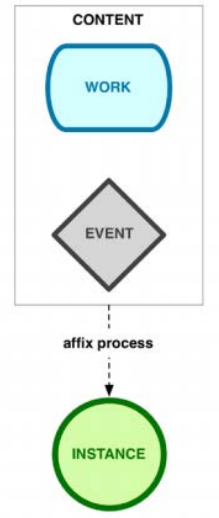

Figure 1. Content Creation Domain Model

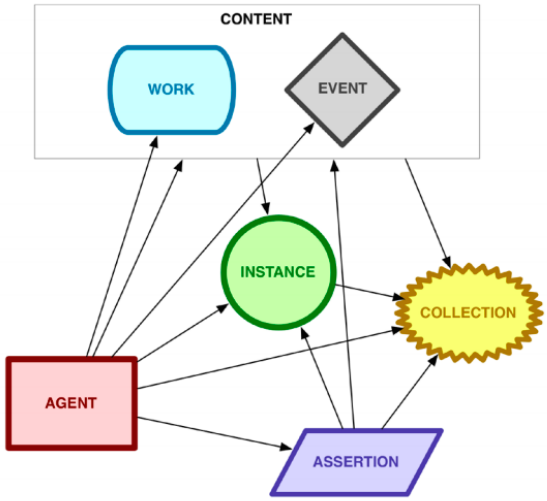

Figure 2. Content Description Data Model

An Instance, then, in terms of audiovisual resources, is a resource reflecting an individual, material embodiment of a Work and/or an Event in space and time.[8] The composition of an AV Instance, however, is one that can come in a range of complexity and structure. A commercial LP copy of The Beatles’ Revolver album is an Instance. A multi-disc CD of the same album with additional behind-the-scenes interviews is yet another Instance. A digital preservation BWF audio file of the commercial LP is a separate Instance. Each of these Instances offers different levels of structural complexity in how they are physically, or digitally, constructed. For example, the LP Instance is a single physical vinyl object with sections of spiral grooves that carry encoded sonic information. The multi-disc CD Instance is composed of two plastic optical discs each carrying digital information in the presence or absence of miniscule pits in a metallic layer embedded within the plastic substrate. The BWF audio file is a machine-readable sequence of bytes composed of an outer format (WAVE-RIFF) and multiple streams of encoded information within the format, including encoded audio (Linear PCM), descriptive data (BEXT and INFO chunks), and embedded song lyrics (aXML packets). Video, film, and digital cinema

[7] Note that the Library of Congress put out a proposal in October 2015 to incorporate an Event model into BIBFRAME based on the previously mentioned BIBFRAME AV modeling study. (http://www.loc.gov/bibframe/docs/pdf/bf2-draftspecevents-10-29-2015.pdf)

[8] Derived from the definition as provided by BIBFRAME (http://www.loc.gov/bibframe/docs/model.html). The text, “or an Event in space and time,” was appended in light of our previous BIBFRAME AV modeling study (http://www.loc.gov/bibframe/pdf/bibframe-avmodelingstudy-may15-2014.pdf).

resources only increase in internal complexity with the option to contain multiple tracks of data (video, audio, text, etc.). In this report we refer to encodings, streams, and data packets as sub-Instance structures.

As a matter of establishing scope for description within the BIBFRAME context, we proceed from the foundation that users of BIBFRAME resources will be most interested in descriptions of the significant characteristics of the resource as an Instance — whether such characteristics are technical, structural, or preservation attributes — not of these sub-Instance structures themselves. **We therefore propose limiting BIBFRAME Instance to a flat structure; complete descriptions of sub-Instance structures (e.g., tracks, bitstreams, filestreams, frames, component parts) should be handled in depth by preservation and audiovisual-specific namespaces outside of the bibliographic context.**

All recommendations in this study proceed from the perspective of limiting the specificity of structural elements (e.g., bitstreams, filestreams) that are described at the Instance level in BIBFRAME for the purposes of bibliographic description. When attributes that can be identified at a sub-Instance level constitute a significant characteristic of the Instance as a whole, their description may be applicable within BIBFRAME (e.g., encoding format of an audio track within a digital video resource). However, it is our opinion that other environments, i.e., preservation systems and/or audiovisual-specific production environments, are in most need of, and are most suited to, capture and manage comprehensively the granular structural, technical, and preservation characteristics of audiovisual resources, and that **this level of detail exceeds the function of bibliographic description***.* PREMIS is suited, with its object model, to manage tracks, streams, and other sub-Instance structures as unique resources to which attributes, events, and relationships may be asserted for the purposes of ongoing digital lifecycle management. Metadata standards from the broadcast industry such as EBUCore[9] and PBCore,[10] which are explored later in the report, are suited to document the granular structure of audiovisual resources and corresponding technical attributes, and, when included under objectCharacteristcsExtension in a PREMIS object, or as standalone records, are excellent options for use in audiovisual-specific production and collection management environments. This proposal also aligns with the current structure and granularity of MARC and the various content standards in wide use today.

While we explore the specifics of this proposal further in Section 2 below, it is an important foundation that underlies our recommendations for BIBFRAME's role as a system of bibliographic description for audiovisual resources.

Report Sections

Based on the above conceptual viewpoints, and the overall aims of the study, this report is structured in three distinct sections:

[9] The European Broadcast Union's Tech 3293 (EBUCore) provides the framework for descriptive and technical metadata for use in service oriented architectures and audiovisual ontologies for the semantic web and linked data developments. Available from: https://tech.ebu.ch/MetadataEbuCore.

[10] Designed by public broadcasters in the U.S., PBCore is a standard to describe media, both digital and analog. Available from: http://pbcore.org/.

- **Section 1: Preservation Metadata** — This section evaluates the relationship between the BIBFRAME Instance and Item entities and the PREMIS Object entity, as well as the role of PREMIS Events in light of AVPreserve's previous recommendation for BIBFRAME Events (as illustrated in Figures 1 and 2 above).

- **Section 2: Structural Metadata** — This section explains our recommendations for how BIBFRAME should conceive of structural metadata for audiovisual resources. Specifically, the study analyses the effect of the complex structure of audiovisual resources on the BIBFRAME model and evaluates whether existing relationship elements in BIBFRAME are suitable to handle the needs of AV resources. As seen above, our conceptual model minimizes the need to document certain complexities of audiovisual structure within BIBFRAME, proposing that when significant to the use of the resource, BIBFRAME should support description of these sub-Instance characteristics without reliance on structural description itself; when not significant, such full description of sub-Instance structures should be left to the requisite environment in which such description is needed.

- **Section 3: Technical Metadata** — This section presents an analysis and recommendations surrounding the expression of audiovisual technical metadata in the context of BIBFRAME. It offers a recommended set of technical attributes that should be supported within the BIBFRAME context, whether through the extension of the BIBFRAME 1.0 vocabulary or through the incorporation of existing RDF ontologies that support the expression of the recommended attributes. After careful review of existing content standards, structural standards, and de facto practices within the bibliographic and audiovisual communities, we feel that our proposed attribute set will provide an opportunity for BIBFRAME to offer leadership and set a standard for the assertion of audiovisual resource attributes in the linked data environment.

In the aforementioned OCLC and LC co-report on the progress of BIBFRAME and the relationship between LC's BIBFRAME and OCLC's use of Schema.org and BiblioGraph.net in WorldCat, the authors propose to "develop and test an implementation of a common model of one or more resource types held by libraries that are not easily describable in BIBFRAME or in Schema.org, such as maps or audiovisual materials."[11] We hope that the results of this study can be used as a foundation for carrying forward such a proposal.

Throughout this report and its appendices we make use of namespace prefixes when referring to classes or properties from specific vocabularies, as follows:

- BIBFRAME - @prefix bf: <http://bibframe.org/vocab/>
- PREMIS - @prefix premis: <http://www.loc.gov/premis/rdf/v1#>
- EBUCore - @prefix ebucore: <http://www.ebu.ch/metadata/ontologies/ebucore/ebucore#>
- Schema.org - @prefix schema: <http://schema.org/>
- RDA - @prefix rda: <http://rdaregistry.info/Elements/>
- W3C Ontology for Media Sources - @prefix ma: <http://www.w3.org/ns/ma-ont#/>

[11] Godby and Denenberg, pg. 11.

Section 1: Preservation Metadata

In this section we explore the question of the scope of BIBFRAME versus PREMIS by exploring the data model of each and proposing a functional mapping between them.

Instance / Object Model

As noted in the Assumptions above, all recommendations proceed from the proposal of limiting bf:Instance to a flat structure. Although filestreams and bitstreams may be present in a given digital bf:Instance, the goal of BIBFRAME as a system of bibliographic description should be to describe their significant characteristics as part of that Instance, rather than to document the structural aspects of the bf:Instance. Therefore, a digital video file with one video track, four audio tracks (two of which feature different languages), and a subtitle track would not be described at the track level in BIBFRAME, rather, the presence of those distinct features (multiple languages, subtitles) would be stated as part of the bf:Instance. Also, as noted in the introduction of this report, although the scope of BIBFRAME is wider than simply access and discovery, it also does not cover the full scope of collections management functions. It is our opinion that other environments, i.e., preservation systems, are in most need of, and are most suited to, capture and manage comprehensively the granular, structural, preservation characteristics of audiovisual resources.

As a preservation metadata vocabulary PREMIS is suited, with its object model, to manage tracks, streams, and other sub-Instance elements as unique resources to which attributes, events, and relationships may be asserted for the purposes of ongoing digital lifecycle management. In this section, we propose a mapping between BIBFRAME and PREMIS to support the use of both vocabularies for their distinct functions.

The PREMIS 3.0 data model includes 4 sub-classes/entities of Object: intellectual entity, representation, file, and bitstream, with the following definitions:[12]

- **premis:Object**: A discrete unit of information subject to digital preservation. The object class aggregates information about a digital object held by a preservation repository and describes those characteristics relevant to preservation management.
- **premis:IntellectualEntity**: A distinct intellectual or artistic creation that is considered relevant to a designated community in the context of digital preservation: for example, a particular book, map, photograph, or database. An Intellectual Entity can include other Intellectual Entities; for example, a Web site can include a Web page; a Web page can include an image. An Intellectual Entity may have one or more digital representations.
- **premis:Representation**: is the set of files, including structural metadata, needed for a complete rendition of an Intellectual Entity. For example, a journal article may be complete in one PDF file; this single file constitutes the Representation. Another journal article may consist of one SGML file and two image files; these three files constitute the Representation. A third article may be represented by one TIFF image for each of 12 pages plus an XML file of structural metadata showing the order of the pages; these 13 files constitute the Representation. Starting

[12] All definitions taken from PREMIS Data Dictionary for Preservation Metadata version 3.0. Available from: http://www.loc.gov/standards/premis/v3/premis-3-0-final.pdf.

with PREMIS version 3.0 physical items, such as manuscripts or printed documents, may also be Representations so that digital and non-digital Representations can be captured uniformly.
- **premis:File**: is a named and ordered sequence of bytes that is known to an operating system. A File can be zero or more bytes and has a File format, access permissions, and File system characteristics such as size and last modification date.
- **premis:Bitstream:** is contiguous or non-contiguous data within a file that has meaningful common properties for preservation purposes. A Bitstream cannot be transformed into a standalone file without the addition of file structure (headers, etc.) and/or reformatting the Bitstream to comply with some particular file format.

In order to determine the relationships between these classes and those available in BIBFRAME, we narrowed down the scope of potentially applicable BIBFRAME 1.0 classes to bf: Work, bf:Instance, and bf:HeldItem, which are defined as:[13]

- **bf:Work**: Resource reflecting a conceptual essence of the cataloging resource.
- **bf:Instance**: Resource reflecting an individual, material embodiment of the Work.
- **bf:HeldItem (or the proposed bf:Item class)**: Tracked physical or digital form of an Instance.[14]

As bf:HeldItem is a sub-class of bf:HeldMaterial, which is a sub-class of bf:Annotation, it is important to also examine the definition of this super-class:

- **bf:Annotation**: Resource that asserts additional information about other BIBFRAME resources.

The BIBFRAME Annotation Model explains that the purposes of bf:Annotation are to:
- Express opinions about a resource, for example a review.
- Attach institution specific information, for example holdings.
- Contribute enhancements to a resource description, for example cover art or summary descriptions.[15]

The specification additionally notes that Annotations are *extrinsic* to the resource they describe.

Additionally, regarding the possibility of a new bf:Item class, the current proposal recommends the following properties can be associated with the class:

- bf:identifiedBy
- bf:componentOf
- bf:hasComponent

[13] http://bibframe.org/vocab-list/
[14] The Library of Congress has put forward a proposal to merge bf:HeldItem and bf:HeldMaterial into a single BIBFRAME Class called bf:Item (http://www.loc.gov/bibframe/docs/pdf/bf2-draftspecitems-10-29-2015.pdf). In this report, we assume the likelihood of the bf:Item amendment. Readers can associate bf:HeldItem with the forthcoming bf:Item. For our purposes, these represent a similar concept — a tracked physical or digital form of an Instance held by an organization with a specific storage location.
[15] Ray Denenberg (Library of Congress), et al, "BIBFRAME Annotation Model," BIBFRAME Community Draft, 26 August 2013. Available from http://bibframe.org/documentation/annotations/. However, note that the aforementioned Item paper suggests that in BIBFRAME 2.0 Annotation will no longer be a BIBFRAME Core class.

- bf:hasNote
- bf:usageAndAccess
- bf:hasCondition
- bf:enumerationAndChronology
- bf:electronicLocator
- bf:heldBy
- bf:hasHolder
- bf:itemOf
- bf:subLocation.

These Properties clearly focus on the location, ownership, relationships, and accessibility of a resource from the perspective of the holding institution. The bf:Item is an object on a shelf with a barcode, or a file on a drive with a file path. The bf:item Class does not offer the ability to document the technical characteristics (or descriptive characteristics) of this resource. We assume that such technical features are documented at the level of bf:Instance. The same holds true for bf:heldItem as it exists currently. In this study we assume the bf:Item (or bf:heldItem) is the tracked physical or digital form of the bf:Instance. Multiple bf:Items would be associated with a bf:Instance if and only if those bf:Items are exact duplicates of each other (e.g., three duplicate cassette copies of Led Zeppelin IV). A CD copy of Led Zeppelin IV (a bf:Item) and a cassette copy of Led Zeppelin IV (a bf:Item) would each be associated with different bf:Instances of the bf:Work Led Zeppelin IV. The technical characteristics and the descriptive characteristics would be differentiated at the bf:Instance level.

Given the above we propose the following mapping between BIBFRAME and the PREMIS Object classes:

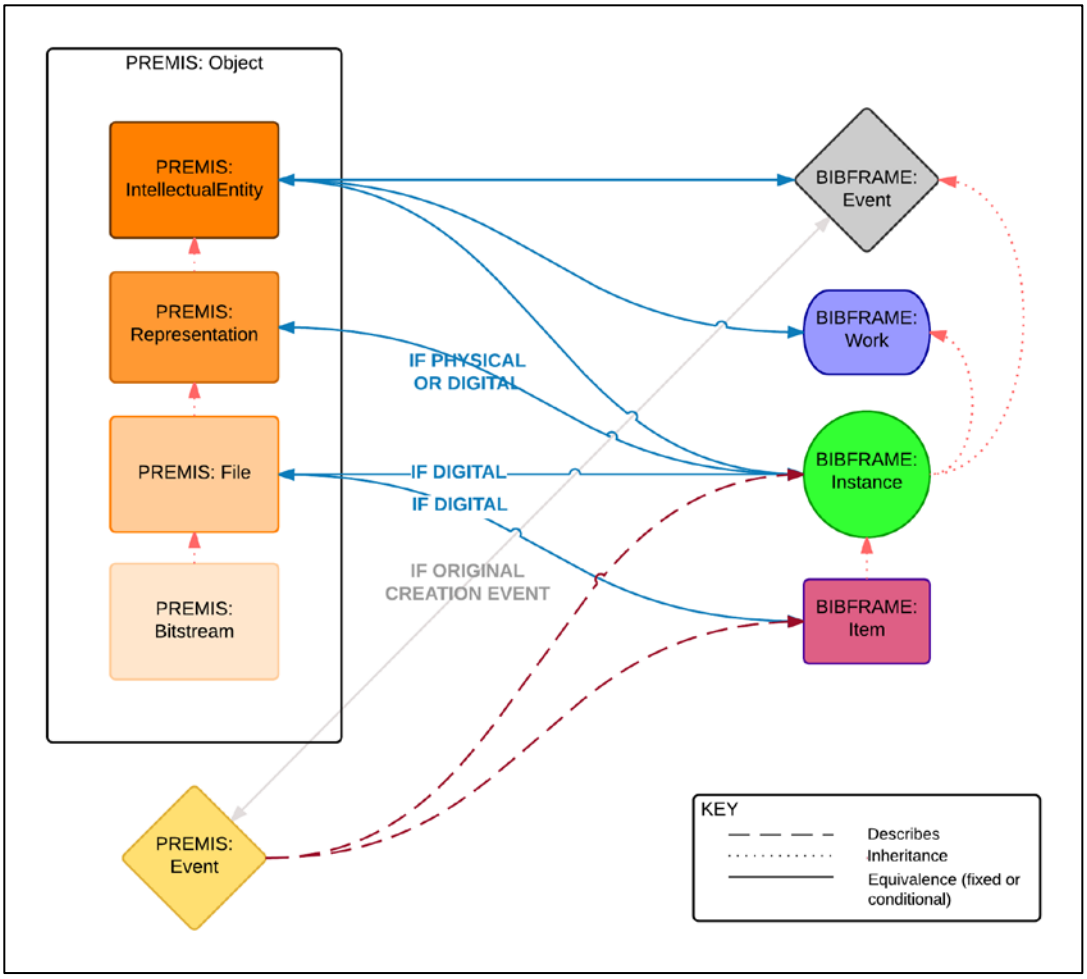

Figure 3. Proposed PREMIS Object → BIBFRAME conceptual mapping

In our interpretation of the provided respective class definitions, we conclude the following:

- A premis:IntellectualEntity can map to either bf:Work, bf:Event (as described in the 2014 BIBFRAME AV modeling study, further described in the section on Event models below), or bf:Instance. For the purposes of PREMIS, bf:Work, bf:Event, and bf:Instance may be used as external namespaces to describe premis:IntellectualEntities.

- As a self-contained resource, a bf:Instance may be the target of preservation, and therefore, depending on the type of resource (physical versus digital) and local and application-specific modeling rules, bf:Instance may also map to either premis:Representation or premis:File. Since a premis:Representation can be a physical or digital resource, this class can easily map to a bf:Instance. A premis:file may map to a bf:Instance only when the Instance is digital.

- premis:Bitstream, as a sub-Instance structure, does not map directly to any BIBFRAME resource, only to the parent PREMIS Object (which itself might map to a BIBFRAME resource), since bf:Instance should be a self-contained resource.

- As it stands, a bf:HeldItem (or bf:Item) can map to a premis:File, however only location and access information is going to be found in the bf:Item record. If bf:Instance is the actual physical

or digital embodiment of the resource, then extrinsic statements about that resource described using bf:HeldItem (or bf:Item) would not include intrinsic properties of a bf:Instance which may be the target of preservation as a premis:Object.

- A premis:Event describes bf:Instance and bf:Item. Only in the scenario when the premis:Event results in the original creation of new content does the premis:Event map to the bf:Event.

Using this mapping, it is possible that technical statements describing BIBFRAME Instances may be used as part of a set of statements about a PREMIS Object. The following diagram demonstrates the overlap of BIBFRAME and PREMIS entities using the above mapping in the description of a commercial audio resource in the care of an organization that also provides preservation services for its audiovisual collections.

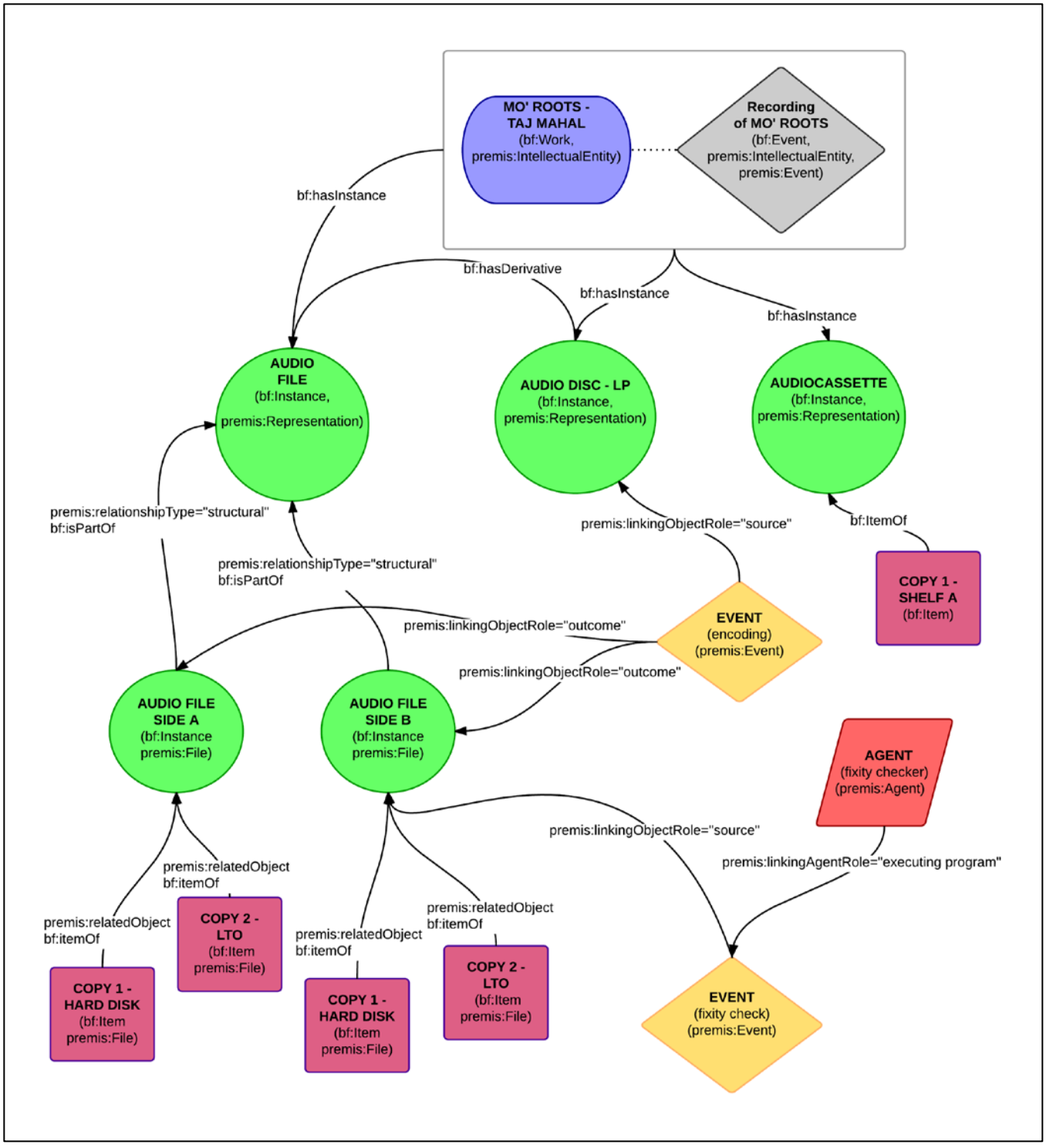

Figure 4. Example PREMIS and BIBFRAME conceptual mockup

Event Model

As both PREMIS and BIBFRAME have identified classes for Event, it is also important to disambiguate these terms. The definitions provided for each are as follows:

- **bf:Event**: Time or place of an event. Available properties of bf:Event include bf:event, bf:eventAgent, bf:eventPlace, and bf:eventTime.[16]
- **premis:Event**: The Event entity aggregates information about an action that involves one or more Object entities. Metadata about an Event would normally be recorded and stored separately from the digital object. Whether or not a preservation repository records an Event depends upon the importance of the event. Actions that modify objects should always be recorded. Other actions such as copying an object for backup purposes may be recorded in system logs or an audit trail but not necessarily in an Event entity. Mandatory semantic units are: eventIdentifier, eventType, and eventDateTime.[17]

In the 2014 AV Modeling Study, we proposed an expanded definition of the bf:Event class, which would enable it to be used to document events that occur in time and space that are captured and affixed in a bf:Instance, either in relation to a bf:Work or independently if no work is part of the documented event. An example of the former includes a live performance of Beethoven's 5th Symphony, and of the latter would be the recording of the beating of Rodney King, which was not documented as a distinct intellectual creation (the common definition of the term "work" in the library community), but rather as evidence of an event in time and space. In this expanded model, we propose including additional properties such as bf:eventType.

Using the above definitions and our own proposal from the AV Modeling Study, we propose fairly distinct uses for bf:Event and premis:Event. Looking at Figure 4 above, it is clear that the PREMIS Events represented here are specifically preservation events — one describes an analog-to-digital migration event, and the other a fixity check on one digital object. In both cases, it can be assumed that some individual or series of Agents (whether software or hardware) was responsible for the event. The PREMIS events identified explicitly enable statements to be made about lifecycle events that support the persistence of content. Because the scope of BIBFRAME as we see it largely excludes preservation, we recommend that the PREMIS event model be used to document these sorts of preservation activities.

In contrast, a BIBFRAME event would not be used to document events related to the persistence of content, but rather to the original content creation. Although, by the AAA principle of the semantic web (Anyone can say anything about anything)[18], there is nothing preventing a user from documenting preservation event using the BIBFRAME vocabulary (and indeed the addition of a bf:eventType property would further enable this), if the definitions of two Event classes are explicit and clear, the semantic distinctions should be understandable.

Therefore, it is our conclusion that PREMIS Events have no real relation to the BIBFRAME Event as proposed in the first BIBFRAME AV study, except for the semantic label and the distinct scenario when an event is documented as the original creation of content resulting in a bf:Instance. A PREMIS Event connects an agent and an outcome to a unique and individual resource within the PREMIS environment, and such Events are repeatable upon said object over time. The BIBFRAME time-and-space Event proposal functions as a mechanism to link agents, locations, and dates to a singular, non-

[16] http://bibframe.org/vocab/Event.html
[17] http://id.loc.gov/ontologies/premis.html#Event
[18] http://www.w3.org/TR/2002/WD-rdf-concepts-20020829/#xtocid48014

repeatable affixation of information to an Instance. An Instance may not be re-affixed during its lifecycle without resulting in a distinctly new Instance.

Other Preservation Metadata

Existing MARC records record preservation activities in field 583 for all resource types, not only audiovisual resources. In our mapping, these activities certainly apply to both BIBFRAME Instances and to PREMIS Objects. If these data are not mapped to BIBFRAME during transformation from MARC, they will potentially be lost. Modeling the migration of this information to BIBFRAME, however, is outside the scope of this study. We have focused on digital preservation activities because audiovisual resources must ultimately be preserved as digital objects. MARC 583 preservation activities must be modeled for all resources, incorporating feedback from a broader library contingent.

Section 2: Structural Metadata

In this section we look at the variably complex structure of audiovisual resources in the context of the BIBFRAME model and, picking up on the Assumptions section above, further evaluate whether existing relationship elements in BIBFRAME are suitable to handle the needs of AV resources. As seen above, our conceptual model minimizes the need to document certain complexities of audiovisual structure within BIBFRAME, proposing that when significant to the use of the resource, BIBFRAME should support description of attributes that are present at the sub-Instance level; when not significant, such full description of sub-Instance structures should be left to the requisite environment in which such description is needed.

Describing Structure in Audiovisual Resources

Digital audiovisual files are complex objects. Even a simple video file, for example, is typically composed of one video track and one or more audio tracks, which are bitstreams within the file structure. Strictly speaking, characteristics of the video file that are unique to either its audio and video aspects, such as the frame rate (video), aspect ratio (video), or sampling rate (audio), are part of those bitstreams. Video files may also have subtitle or closed caption text tracks. All of these bitstreams are packaged in a container, or “file” (which has a “file format”), and which, in BIBFRAME, is what would be considered an Instance. Figure 5, below, illustrates this scenario with an example of an MXF file containing video, audio, time code, and closed-caption streams.

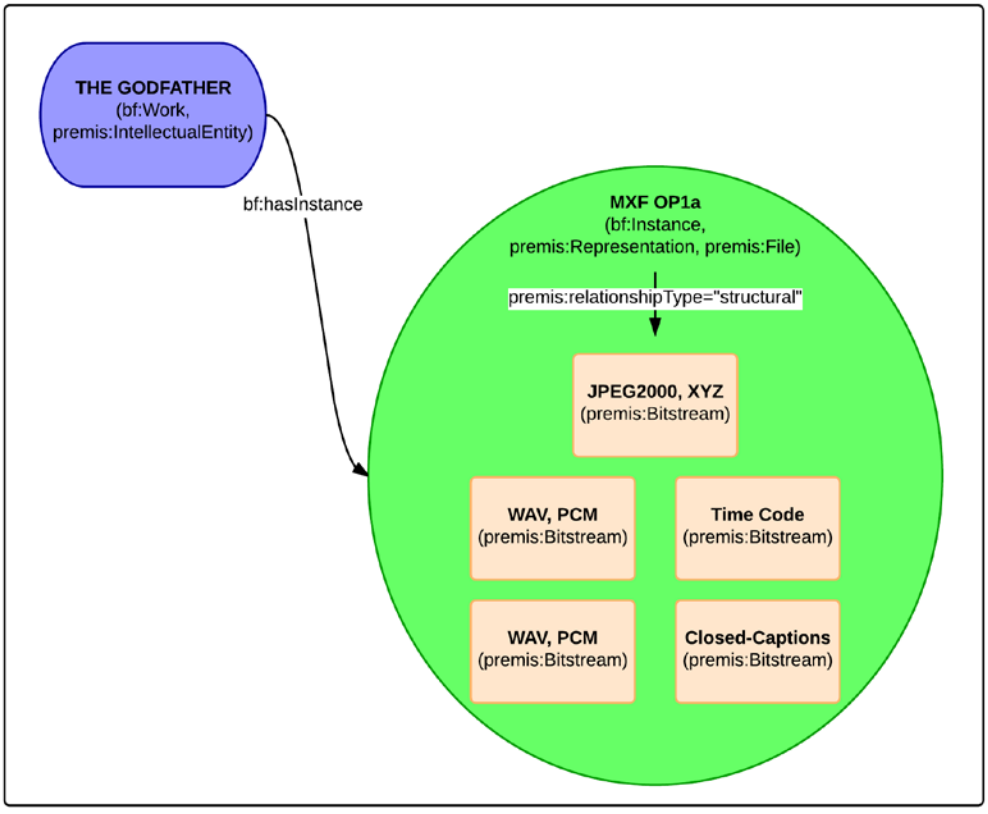

Figure 5. Illustration of the technical complexity of MXF video resources

As previously noted, we feel strongly that the scope of BIBFRAME (and of bibliographic description) should support the ability of a cataloger to describe the technical attributes of the resource at the Instance level, but that it would be technically inefficient and unnecessary for a cataloger to describe, in repetition, each filestream (considered “files” within other “files”) or bitstream (tracks within a multimedia file) that constitutes an audiovisual resource, and therefore unnecessary to establish each stream as an independent resource within BIBFRAME in order to document structural relationships between streams and files. In this example, we propose that the MXF OP1A file be described as a bf:Instance. Within this Instance, the significant attributes of the overall package, including the video and audio encoding formats found at the bitstream level, as well as the presence of closed-captions and even potentially time code, would be expressed as part of that bf:Instance as these attributes serve multiple bibliographic purposes. However, the description of the structure of the MXF package itself would be left to a PREMIS environment. Within PREMIS, the bitstreams may either be collectively described at the premis:File level within an objectCharacteristics statement, or as separate premis:Bitstream objects with a structural relationship to the premis:File. Depending on the implementation, there may or may not be some redundancy between the characteristics expressed within PREMIS and BIBFRAME, but the overall granularity would likely be quite different, and furthermore, different within various application environments.

As another example, in the case of a digital cinema package (DCP), a cataloger will encounter four XML files and two MXF files. These six files together comprise the motion picture resource. In the scope of BIBFRAME, the technical attributes should document the significant properties of the resource as an Instance, and not a comprehensive analysis of the technical attributes of each file in the package. In such a case each file would need to be described as a unique BIBFRAME resource in order to describe its technical attributes or structural relationships. This would do injustice to the agile and relatively flat model of RDF. However, we do feel that the encoding format of each track is as important to the user as knowing the container format, so we do recommend in the proposed set of technical attributes that BIBFRAME provide properties that allow a cataloger to document the presence and encoding format of any audiovisual stream (audio encoding format, video encoding format) within a bf:Instance.

In the illustration below, the DCP is the bf:Instance that will be described in terms of technical attributes. Elements of the files contained in the package will be documented, e.g., encoding of the audio and video streams, color space of the video stream, sample rate of the audio stream. These will add up to the technical description of the Instance, however not each file will be described as an individual resource.

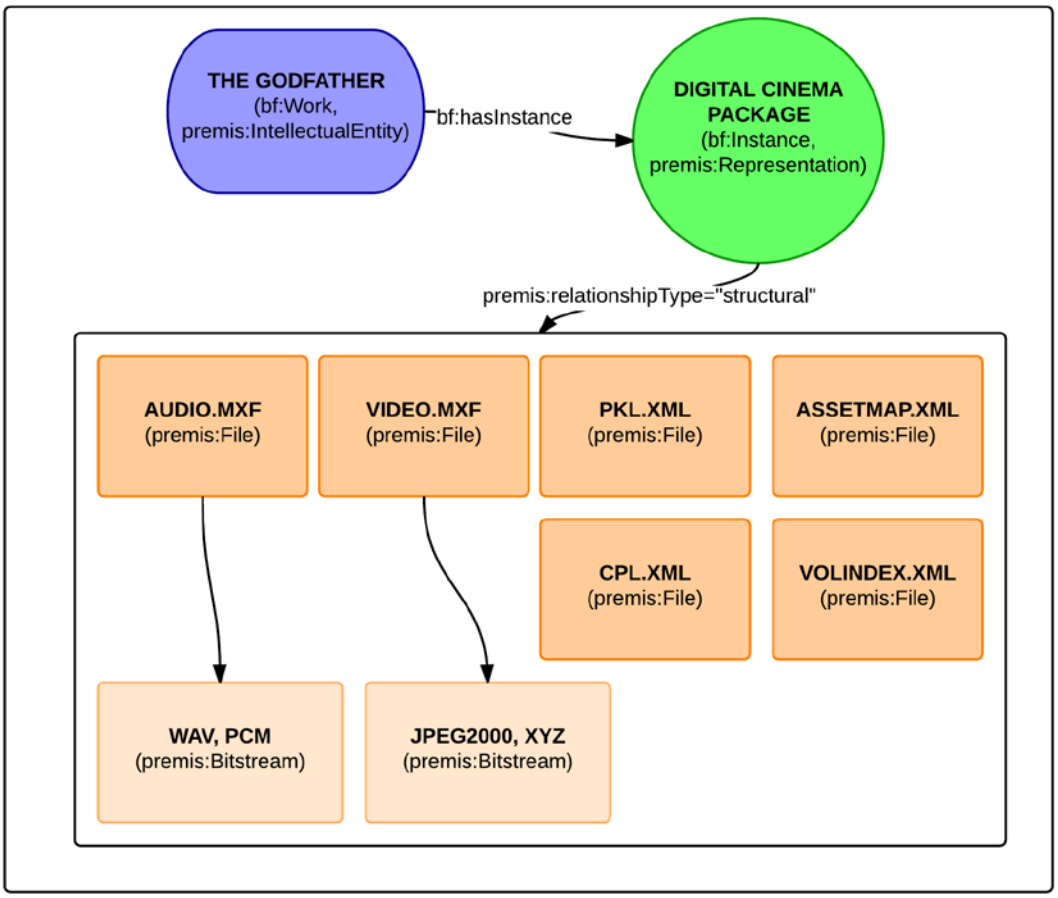

Figure 6. Illustration of the technical complexity of Digital Cinema Package resources

A similar example follows, illustrating what a cataloger would see when describing a DPX image sequence for digital film scanning. The motion picture resource, in this case, is composed of thousands of DPX image files (akin to the individual frames found on motion picture film). In BIBFRAME, a cataloger would describe the DPX image sequence resource at an aggregate (Instance) level, and not each of the thousands of individual DPX files. Implementations of EBUCore or PREMIS could describe each DPX file if an organization desired to do so, however these implementations are out of scope for BIBFRAME uses.

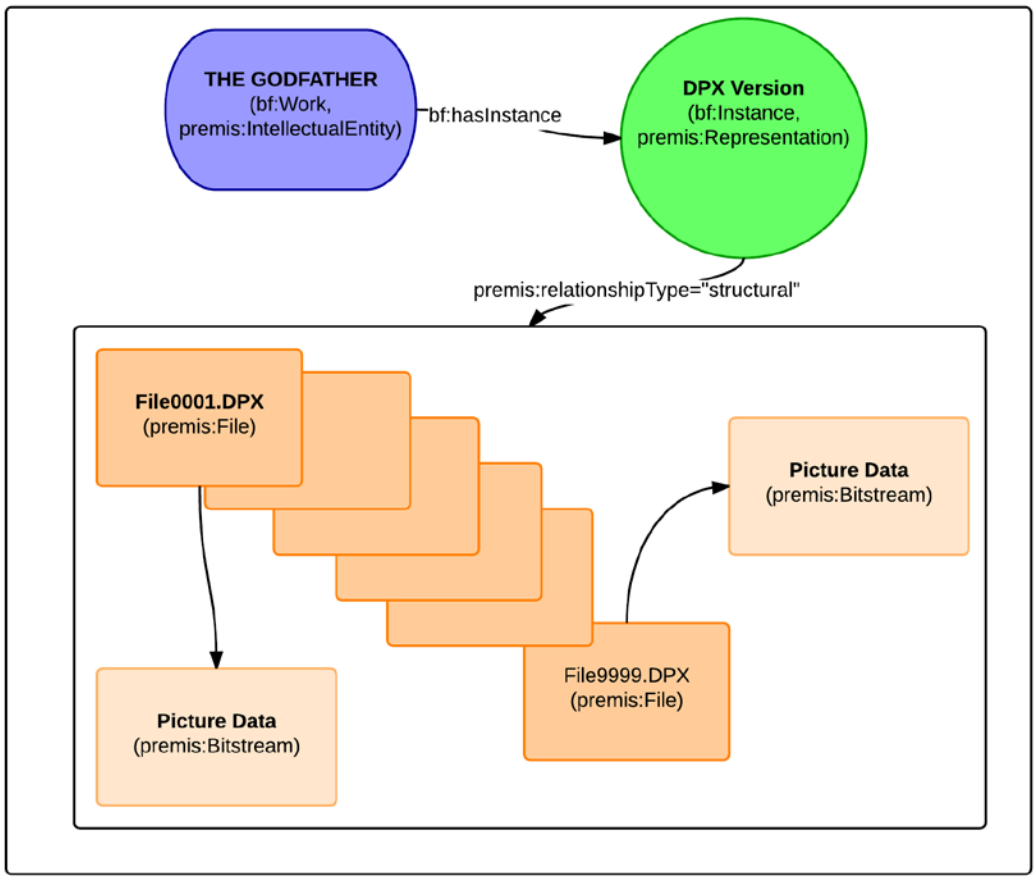

Figure 7. Illustration of the technical complexity of DPX (digital film) resources

While the hierarchical structure of an audiovisual file can and should be documented in preservation environments and audiovisual production environments, we recommend and feel that it is sufficient to capture the presence of audio and visual tracks via the encoding format and other significant characteristics of said video and audio tracks (e.g., frame rate or aspect ratio) for the purposes of bibliographic description.

This proposal also aligns with the W3C Ontology for Media Sources (@prefix ma: <http://www.w3.org/ns/ma-ont#>), which refers to characteristics of media resources that technically are at the track level, but proposes a flat structure that better serves users of media resources on the web, according the following technical attribute set:

- ma:frameWidth
- ma:frameHeight
- ma:frameSizeUnit
- ma:hasCompression
- ma:duration
- ma:hasFormat
- ma:samplingRate
- ma:frameRate
- ma:averageBitRate

- ma:numberOfTracks
- numTracks.type[19]

Other vocabularies, particularly those that are used in the audiovisual production world such as EBUCore and PBCore do support sub-Instance structural description. Although in Section 3 we select EBUCore as an exemplary standard to demonstrate availability of similar audiovisual technical properties in an RDF vocabulary, it is important to note that because of EBUCore's hierarchical approach to technical description, there may be incompatibilities applying EBUCore RDF properties in the BIBFRAME environment. For example, where an EBUCore property ebucore:encodingFormat is employed in a domain that has the conceptual equivalent of a track (i.e. bitstream), BIBFRAME usage would be in the domain of a class of bf:Instance. We do not agree that "Track" and "Instance" are equivalent classes and it is possible that using the EBUCore property ebucore:encodingFormat to describe a BIBFRAME instance would not be RDF best practice and would invite illogical inferences.

[19] Should be represented as subproperties of the original property (ma:numberOfTracks) using the RDF ontology.

Section 3: Technical Metadata

The results of this section of inquiry provide recommendations for what audiovisual technical metadata should be supported by BIBFRAME, and proposes how BIBFRAME could support these attributes in the scope of bibliographic discovery within a linked data environment.

Because BIBFRAME itself is still under development, we are aware that some of our recommendations will simply be questions that require further investigation or depend on the results of parallel developments in the direction of BIBFRAME. It is apparent that BIBFRAME's developers have made efforts previously to map elements of existing technical metadata for audiovisual materials from MARC fields to BIBFRAME 1.0 properties. During this assessment, we take these mappings into account, but we also proceed with the knowledge that these mappings are malleable in this current state of BIBFRAME development. If evidence suggests so, we recommend alternate mappings or new properties altogether.

Methodology

As a foundation for beginning this analysis, we evaluated how existing formats for resource description (i.e., MARC 21 formats for Bibliographic Data[20]) serve as carriers for audiovisual technical metadata. Because MARC 21 is the current bibliographic encoding standard, and is the target that BIBFRAME is intended to replace, our initial approach was to itemize extant fields (i.e., a variety of 3xx fields, and 007 fixed fields) within MARC that support the expression/encoding of technical metadata for audiovisual resources. The purpose here is twofold: to understand the full universe of technical audiovisual properties/attributes that can currently be encoded and expressed in MARC; and to understand in which fields this audiovisual technical data may be stored in MARC (which will be useful when designing MARC to BIBFRAME transformations). The results of this analysis can be found below in the **Findings**.

We also approach this evaluation from the perspective of existing library content standards, as these provide catalogers with the guidelines for metadata creation. Our assumption is that the usage of existing fields in an encoding standard such as MARC, and BIBFRAME in the future, will be heavily influenced by the emphasis placed on the expression of technical attributes in these content standards.

For the purposes of this study, we examined both generally applicable and widely adopted standards as well as more specialized AV description standards, as follows:

- Resource Description and Access (RDA)
- Anglo-American Cataloging Rules version 2 (AACR2)
- International Standard Bibliographic Description (ISBD)
- Archival Moving Image Materials: A Cataloging Manual (AMIM)
- International Association of Sound and Audiovisual Archives Cataloging Rules (IASA)
- Music Library Association Best Practices for for Music Cataloging (MLA)
- International Federation of Film Archives Cataloging Cataloging Manual (FIAF), November 2014 draft

[20] http://www.loc.gov/marc/bibliographic/

Our approach in analyzing these content standards was to look specifically at the technical attributes that they recommend for audiovisual materials, and create a logical mapping across them, which can be seen in **Appendix A** (AppendixA_TechMD_Gap_Analysis.xlsx**)**. For each standard, we noted all applicable technical attributes, any vocabularies recommended by each. We also noted to which media types the standard ascribes the attribute using a custom system of media type codes, as defined in Table 1 below:

Code	Description	Notes
F-P	Film physical	Traditional motion picture film, including 35mm, 16mm, etc.
F-F	Film file-based	Digital cinema packages composed of one file-based image per frame, metadata that instructs playback functionality, and an optional file-based soundtrack, such as DPX (these are also known as "image sequences"), or packages of serialized image files, audio files, and XML files such as the DCP or MXF OP Atom specifications.
V-PA	Video physical analog	Physical, analog video, such as 1" open reel, ¾" U-Matic, Betacam SP, and VHS
V-PD	Video physical digital	Physical digital videocassette formats such as Digital Betacam and Mini DV or authored discs such as DVD and BluRay
V-F	Video file-based	File-based video such as QuickTime (.mov) or MP4 (.mp4). Files stored as data on optical media would fall under this category
S-PA	Sound physical analog	Physical, analog sound formats such as grooved discs, ¼" open reels, and audiocassettes
S-PD	Sound physical digital	Physical digital audiocassettes such as DAT, or authored optical discs such as CDs
S-F	Sound file-based	File-based sound such as WAV (.wav) or MP3 (.mp3). Files stored as data on optical media would fall under this category

Table 1. Audiovisual media type codes used in this study

In Appendix A, if a content standard only recommends that a given attribute be used for video, and is specific to physical videotape in particular, only the V-PA and V-PD boxes are checked. This coding system is also employed in Appendix C, as described below.

Next, as additionally documented in Appendix A, we looked across the content standards and prescribed a generic label to each of these technical attributes. We then cross-referenced where these attributes could be expressed in MARC, and noted the relevant tags. Similar to the coding of attributes to media type in the content standard evaluations, we noted what MARC media type the field was specific to, whether moving image, sound, video, or electronic, in this case using the MARC media type designators as opposed to our own. Available MARC fields that support the expression/encoding of technical audiovisual metadata and that do not have an equivalent in the content standards reviewed were also documented. We additionally explored the broadcast industry standards PBCore and EBUCore, and noted mappings and gaps from these datasets as compared with the content standards.

Following this, we extracted the generic attribute list created through the complete analysis of extant standards represented in Appendix A to a full set of possible technical attributes for audiovisual

resources, inclusive of the content standards, MARC, PBCore, and EBUCore. This list is represented in **Appendix B** (AppendixB_BIBFRAME_Generic_Attributes.xslx**)**. Here, we evaluated each attribute for its applicability in a bibliographic environment and noted our recommendation of whether the attribute should be in or out of scope for BIBFRAME and why.

The final set of pared-down recommended attributes, their proposed usage, and our recommendation for their applicability across media types (again, using the codes from Table 1)[21] can be seen in **Appendix C** (AppendixC_BIBFRAME_Proposed_AVAttributes.xslx**)**. In order to explore the degree to which these might be expressed in existing vocabularies, we evaluated how the proposed attributes are currently accommodated in the BIBFRAME 1.0 vocabulary as well as other namespaces, including EBUCore, Schema.org, and RDA. Potentially applicable extant object vocabularies were also explored for each attribute.

Three approaches were used for the evaluation of BIBFRAME 1.0's support of each recommended attribute:

1. The full set of currently available BIBFRAME 1.0 properties were reviewed and noted as applicable.
2. To provide context for current (even if not complete) thinking, several MARCXML records for AV materials were gathered from a number of institutions and passed through the MARC to BIBFRAME 1.0 Transformation Service,[22] to see what the resulting output produced for the applicable identified MARC fields (see **MARC Analysis** below for detail on the MARC 300 and 007 fields reviewed). Although the Transformation Service is in a state of change, this gave us an initial sense of current BIBFRAME 1.0 mapping for common properties.
3. We reviewed the existing transformation logic in XQuery (https://github.com/lcnetdev/marc2bibframe) to clarify the results we observed in #2 above.

The narrative that follows throughout the remainder of this report provides further background, insight, and analysis to accompany Appendices A and B, and reveals additional considerations that enabled us to reach the final recommended set of attributes found in Appendix C, as well as our recommendations for how these might be supported by BIBFRAME. In the **Recommendations** section below, we also note remaining questions that have not been fully answered through this study and that would benefit from additional research.

Considerations

Uses of Technical Metadata for AV

Like most bibliographic resources, audiovisual media can be extant as physical or digital objects. They can be measured in the physical world with standard metrics of length, width, and diameter, and in the digital world in terms of bytes. Video and film, like other image formats, can come in a variety of color spaces, including a simple black and white, or a complex color specification such as Technicolor. And like other images, video and film are captured and meant to be seen in specific ratios of width and height at varying levels of informational density. Sound recordings, by nature, are made of the encoding

[21] Note that at times this recommendation differs significantly from the existing usages of the attribute noted in the content standards analysis.
[22] http://bibframe.org/tools/transform/start

of waveforms onto a surface, be it a physical groove, a configuration of magnetic particles, or some expression of 1s and 0s either in pits or as bits. Sometimes certain processing can be applied to the sound to achieve a desired effect or equalization. This recorded sound can be delivered as human ears hear, in stereo, or in a simplified single monaural stream, or even as a batch of multiple simultaneous streams. Sound recordings themselves are often also a part of video recordings and motion picture film, a form of multimediality. Additionally, and in contrast to all other bibliographic resources, audiovisual materials are documents of a span of time — they exist in a temporal space that must be measured in seconds, minutes, or hours. To be experienced, they must be set in motion (reproduced) at a speed that matches the speed at which they were originally recorded. All of these characteristics are examples of the type of information technical audiovisual metadata encompasses.

Discrete Values

In looking at existing MARC datasets, we are mindful that many technical attributes are concatenated and expressed in strings, in fields such as 300$a, $b, and $c. For legacy data migration purposes, these will inevitably be mapped to an equivalent BIBFRAME property (e.g. $a = bf:extent, $c = bf:dimensions). However, best practice for metadata creation and management dictates that each element stores only one value.[23] Parsing legacy data will be very difficult, but moving forward with new data creation, it will be in the best interest of catalogers to create and store granular metadata in explicitly identified properties in order to enable search, faceting, display, and analytics on technical values. The question remains of how to reconcile legacy data with a potentially new practice? If only newly created BIBFRAME records have atomic, modular technical data, how could search faceting be enabled? How will indexes support parsing of existing strings? We recommend that these questions be evaluated in further studies.

Electronic Resources

Many electronic resources are stored on tangible media carriers, e.g., floppy disks, optical discs, hard drives, thumb drives. In most cases, these carriers alone do not provide clues as to the media type of the resources they contain. An optical disc can contain text, still images, sound recordings, moving images, games, software, or many other electronic content types. Identifying an item as an electronic resource does not provide enough specificity to sufficiently document the nature of the contained resource. In cases where the object and the contained content are in union (e.g., a CD containing CD-audio) then the description of the object will provide sufficient information for discovery, use, and curation of the content. However, in cases where the CD contains a mixture of data files (e.g., a CD containing 100 TIFF files, 20 PDFs, and 1 MOV), the description of the optical disc as a resource is not meaningful for understanding the nature of the contained content.

As such, this report does not make use of the concept of “electronic resource.” We feel strongly that this description (except in very few cases, as noted above) does not adequately capture the nature of content, and by itself has extremely limited uses. This is especially true for audiovisual materials. The kinds of descriptors recommended for “electronic resources” by content standards such as RDA and structure standards such as MARC are very much focused on the physicality of a storage device (e.g., categories of material including computer disc, tape cartridge; dimensions of the storage media) or very specific aspects of potential media types that may be contained on those resources. In actuality, these

[23] Indeed, this is the rule of 1st normal form of relational data modeling. Even though we are not doing relational modeling here, this data quality concept is still important. See more: http://en.wikipedia.org/wiki/First_normal_form.

media typically include multiple file objects, which may be a mix of media types. Also, storage media of file-based resources will by nature change, and are not integral aspects of the resource. Therefore, we recommend avoiding description at the level of the storage device, and focusing instead on the file-based media contained within these devices.[24]

Findings

MARC Analysis

Because MARC 21 is the current bibliographic encoding standard, and is the target that BIBFRAME is intended to replace, we evaluated existing fields (007 fixed fields and a variety of 3xx fields) within MARC that support the expression/encoding of technical metadata for audiovisual resources. Although a number of 5xx note fields can be used to store descriptions of technical characteristics, we left these fields out of our analysis because technical information about any type of resource can be encoded here. Predominantly, we evaluated fields that are specific to audiovisual resources, with the addition of fields specific to digital content since audiovisual resources can be encoded as digital files.

007 Fields

There are 36 distinct technical characteristics that can be recorded about audiovisual (and electronic) resources in the 007 physical description fixed field.[25]

[24] We understand that for many years in the 20th century, before practices around digital preservation matured, libraries managed and described content delivered on external electronic media (e.g., 3 ½-inch diskettes, 5 ¼-inch floppy disks). 21st century practice requires the extraction of digital content from physical carriers for management and description as file-based content.

[25] Duration (or run time) is not available in 007. To record duration in a fixed field, catalogers use 008 18-20 (a three-digit value).

Seventeen (17) of these properties can be applied to motion picture film:

007 character position	007 field name
00	Category of material
01	Specific material designation
03	Color
04	Motion picture presentation format
05	Sound on medium or separate
06	Medium for sound
07	Dimensions
08	Configuration of playback channels
09	Production elements
10	Positive/negative aspect
11	Generation
12	Base of film
13	Refined categories of color
14	Kind of color stock or print
15	Deterioration stage
16	Completeness
17-22	Film inspection date

Table 2. MARC 007 fixed fields covering motion picture film technical metadata

The MARC 007 fixed field specifies eight (8) characteristics that can be delineated for video resources.

007 character position	007 field name
00	Category of material
01	Specific material designation
03	Color
04	Videorecording format
05	Sound on medium or separate
06	Medium for sound
07	Dimensions
08	Configuration of playback channels

Table 3. MARC 007 fixed fields covering video technical metadata

There are thirteen (13) properties available to describe the physical characteristics of sound recordings in the 007 fixed field.

007 character position	007 field name
00	Category of material
01	Specific material designation
03	Speed
04	Configuration of playback channels
05	Groove width/groove pitch
06	Dimensions
07	Tape width
08	Tape configuration
09	Kind of disc, cylinder, or tape
10	Kind of material
11	Kind of cutting
12	Special playback characteristics
13	Capture and storage technique

Table 4. MARC 007 fixed fields covering audio technical metadata

Finally, because most contemporary audiovisual resources begin life and persist as digital files, and because most legacy audiovisual resources are being digitized for preservation and access, it is extremely important to be able to document digital file technical metadata when documenting audiovisual technical metadata. The MARC 007 fixed field supports the description of eleven (11) technical characteristics of digital files.

007 character position	007 field name
00	Category of material
01	Specific material designation
03	Color
04	Dimensions
05	Sound
06-08	Image bit depth
09	File formats
10	Quality assurance target(s)
11	Antecedent/source
12	Level of compression
13	Reformatting quality

Table 5. MARC 007 fixed fields covering digital file technical metadata

It is apparent that the developers of MARC 007 were focused on digital files that were generated as surrogates or derivatives of some other resource. In today's libraries, more often than not, "born-digital"

digital files are collected as original resources. Any future bibliographic encoding standard will need to support more detailed technical metadata for digital files.

3xx Fields

There are a variety of MARC 3xx fields that allow for the encoding of technical information about audiovisual resources, although not all of these fields exist exclusively for AV resources.

The following table outlays the 3xx technical characteristics options in MARC for audiovisual and digital resources.

Field	Field Title	Subfield	Subfield Title
300	physical description	a	extent
300	physical description	b	other physical details
300	physical description	c	dimensions
300	physical description	e	accompanying material
300	physical description	f	type of unit
300	physical description	g	size of unit
300	physical description	k[26]	speed
300	physical description	m	manufacturer id number
300	physical description	n	matrix number and/or take number
306	playing time	a	playing time
336	content type	a	content type term
337	media type	a	media type term
338	carrier type	a	carrier type term
340	physical medium	a	material base and configuration
340	physical medium	b	dimensions
340	physical medium	c	materials applied to surface
340	physical medium	d	information recording technique
340	physical medium	f	production rate/ratio
340	physical medium	h	location within medium
340	physical medium	i	technical specifications of medium
340	physical medium	j	generation
340	physical medium	o	polarity
344	sound characteristics	a	type of recording
344	sound characteristics	b	recording medium
344	sound characteristics	c	playing speed
344	sound characteristics	d	groove characteristic
344	sound characteristics	e	track configuration
344	sound characteristics	f	tape configuration

[26] 300 $k, $m, and $n were used in the CANMARC format for pre-AACR2 records and were taken out. (There were also several other fields that had physical description of films and sound recordings that are now obsolete.)

Field	Field Title	Subfield	Subfield Title
344	sound characteristics	g	configuration of playback channels
344	sound characteristics	h	special playback characteristics
345	projection characteristics of moving image	a	presentation format
345	projection characteristics of moving image	b	projection speed
346	video characteristics	a	video format
346	video characteristics	b	broadcast standard
347	digital file characteristics	a	file type
347	digital file characteristics	b	encoding format
347	digital file characteristics	c	file size
347	digital file characteristics	d	resolution
347	digital file characteristics	e	regional encoding
347	digital file characteristics	f	encoded bitrate

Table 6. MARC 3xx fields covering audiovisual and digital technical metadata.

007 - 3xx Comparison

There is a wide overlap between the types of technical metadata that can be stored in 007 fixed fields and 3xx descriptive fields. Not only is there overlap but also certain fields (both 007 and 3xx) can only be applied to resources of a certain type (e.g., Electronic Resources, Sound, Film, and Video), a byproduct of which is that different fields can be used to describe the same technical characteristic but for different resource types. For example, dimensions of recorded sound media are denoted in 007(06) and 007(07) as Dimensions and Tape Width, respectively (the available values of these two fixed fields combine to cover the standard possibilities of audio tape width); but for motion pictures and videorecordings, the same information must be noted only in 007(07) as Dimensions. The dimensions of all three resource types can also be described in both 340b and/or 300c. A detailed matrix of these relationships is available as **Appendix D** (AppendixD_BIBFRAME_007-3xx-Comparison.xlsx**)**.

Accounting for the duplication where 007 and 3xx fields document the same attribute, there are 47 total fields[27] in MARC that support the expression of audiovisual or digital technical metadata.

Trends in AV technical metadata usage in MARC

Using the aggregation of bibliographic data in WorldCat, OCLC recently generated and published yearly statistics of MARC field usage (2013–2015).[28] The following extracts from the OCLC dataset provide background for the usage of audiovisual technical metadata properties in existing bibliographic data. In this analysis, we selected fields and subfields that are specific to audiovisual materials; we excluded any fields that allow for non-audiovisual description.

[27] This figure does not include the usage of 5xx generic note fields.
[28] OCLC, “Ground Truthing the Use of MARC,” accessed at http://experimental.worldcat.org/marcusage/.

MARC Field	Title	Subtitle	2013 (records)	2014 (records)	2015 (records)
344a	sound characteristics	type of recording	199	29,587	312,314
344b	sound characteristics	recording medium	102	16,614	67,830
344c	sound characteristics	playing speed	25	4,899	18,317
344d	sound characteristics	groove characteristic	1	172	3,635
344e	sound characteristics	track configuration	1	357	2,103
344f	sound characteristics	tape configuration	1	21	162
344g	sound characteristics	configuration of playback channels	149	16,053	62,936
344h	sound characteristics	special playback characteristics	16	4,687	20,015
345a	projection characteristics of moving image	presentation format	2	480	2,439
345b	projection characteristics of moving image	projection speed	1	10	706
346a	video characteristics	video format	152	3,659	15,267
346b	video characteristics	broadcast standard	153	4,253	19,052
347a	digital file characteristics	file type	387	46,580	198,399
347b	digital file characteristics	encoding format	534	44,978	173,531
347c	digital file characteristics	file size	12	3,424	18,331
347d	digital file characteristics	resolution	1	329	1,431
347e	digital file characteristics	regional encoding	59	5,622	22,657
347f	digital file characteristics	encoded bitrate	1	165	332

Table 7. A sampling of audiovisual technical metadata fields (MARC) as used worldwide from 2013–2015. Digital file characteristics field usage is included here because of the general trend in collecting and providing access to digital audiovisual materials.

The statistics in Table 7 demonstrate the uptake of RDA-specific audiovisual fields that were made newly available in MARC in 2012 upon the release of RDA. Generally, there is a trend of greater usage of all of these fields, which highlights the importance of the present study to define the procedures and properties for handling audiovisual technical metadata in BIBFRAME RDF. Specifically, we find substantial increased usage of MARC field 344a, 344b, 344g, 347a, and 347b. Figure 8, below, charts the usage of these five fields across three years, 2013–2015, where:

- 344a distinguishes whether a sound recording is digital or analog;
- 347a articulates the general file type of a digital object;
- 347b defines the file format of a digital file;
- 344b documents the original recording medium of a sound recording;
- and 344g notes the configuration of playback channels for a sound recording.

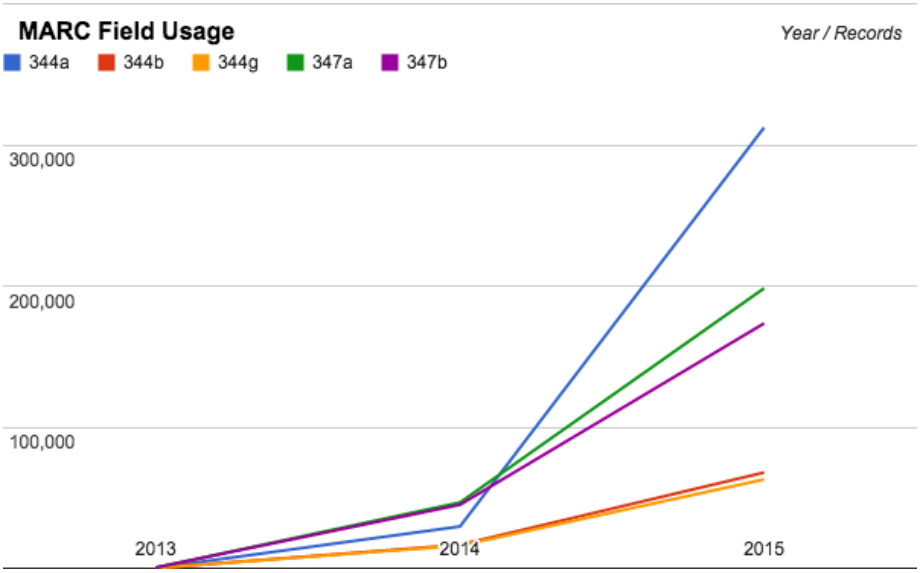

Figure 8. Graph of growing use of selected audiovisual technical metadata fields

Returning to the Table 7 above and looking at these 3xx fields according to the broad formats for which they were designed (344 = sound recordings; 345 = film; 346 = video; 347 = digital files), we see a trend of increased use for all four types, but a dominant growth of technical metadata to document sound recordings and digital files.

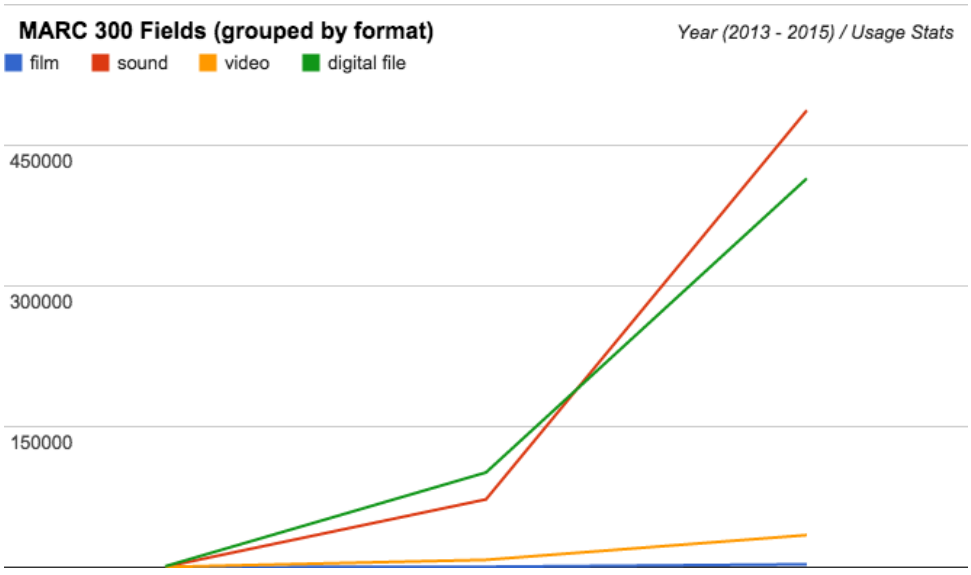

Figure 9. Graph of growing use of 3xx MARC fields that describe audiovisual and digital technical metadata properties

One caveat to note is that there is no way to further qualify “digital files” according to media type (e.g., video, sound, image, text) within this WorldCat dataset. Therefore, although there is clearly an enormous amount of growth in the recording of this information (which does not necessarily indicate a correlation to an increase in collection, acquisition, or reformatting activities), it is unclear what digital media types are growing. The comparison is a bit apples to oranges, but nonetheless interesting given the available data. This is, again, why we disagree with the generic use of terms such as “digital file” and “electronic resource” to describe resources within the same parameter as specific media types

such as “video” or “audio.” Below, we suggest applying “recording method” globally for all object types in order to dissociate between a media type (film, audio, video, etc.) and its recording or encoding mechanism (analog, digital, optical, etc.).[29]

Other MARC fields provide locations for the expression of audiovisual and digital technical metadata properties, including 007 fixed fields and 300, 336, 337, 338, and 340 description fields, but because these fields include the description of all resource types (not only AV), the OCLC data about these fields did not prove useful for purely audiovisual technical metadata analysis.

Content Standards Evaluation and Gap Analysis

Our evaluation of the most well known bibliographic content standards (including an analysis of the MARC fields discussed in the previous section) takes place largely in **Appendix A** (AppendixA_TechMD_Gap_Analysis.xslx)**.** Here we document the technical attributes that the following standards recommend for audiovisual materials:

- Resource Description and Access (RDA)
- Anglo-American Cataloging Rules version 2 (AACR2)
- International Standard Bibliographic Description (ISBD)
- Archival Moving Image Materials: A Cataloging Manual (AMIM)
- International Association of Sound and Audiovisual Archives Cataloging Rules (IASA)
- Music Library Association Best Practices for Music Cataloging (MLA)
- International Federation of Film Archives Cataloging Manual (FIAF), November 2014 draft

In the spreadsheet, the columns related to a given content standard are color-coded. The rows of the spreadsheet demarcate a unique generic technical metadata attribute, e.g., duration, playing speed, or bitrate. For each content standard, we extract from the standard a set of values that are directly related to the documentation of technical metadata for audiovisual and/or digital resources. For each technical attribute for a given content standard, we note the following:

1) Area in the content standard from which the attribute is pulled
2) Specific technical attribute expressed by the content standard
3) Sample of data that would be expressed for the attribute
4) Notes or comments about the nature of the attribute or the application of the attribute as recommended by the content standard
5) Mapping of the content standard to the set of media types as noted in Table 1 above (x = applicable according to standard; o = applicable in reality but not mentioned in the standard; null = not applicable)

The excerpt below demonstrates an analysis of one attribute (dimensions) for one content standard (RDA):

[29] Recording method could support values such as digital, analog, or acoustic.

Generic Attribute	F-P	F-F	V-P	V-D	V-F	S-P	S-D	S-F	RDA area	RDA attribute	RDA sample	RDA notes
dimensions	x		x	x		x	x		3. Describing Carriers	3.5 Dimensions	35 mm; 7 in, 1/4 in	includes gauge, overall dimension, tape width

Figure 10. Excerpt from Appendix A

The Generic Attribute column, located on the far left of the spreadsheet, is used across all standards to map each technical attribute expressed by a given content standard to a generic attribute (allowing us to normalize the attribute description, since content standards often recommend similar attributes, but title them differently). This mapping, over the course of the exercise, led to a list of generic attributes as defined by all the content standards that we evaluated.

Similarly, in this spreadsheet, we evaluate how the MARC fields, as well as external structure standards (i.e., PBCore, EBUCore), and existing BIBFRAME 1.0 properties map to the same generic attributes. When any of these standards cover attributes not covered by any of the content standards, we add new generic attributes.

In the sections that follow, we use the data gathered in this spreadsheet (Appendix A) to discuss the nature of technical metadata support for audiovisual and/or digital resources as expressed in existing bibliographic content standards. We then articulate the generic attribute set uncovered through this analysis of existing content standards. Using the generic attribute set, we perform a gap analysis against MARC, PBCore, and EBUCore to document possible attributes that are currently not covered by bibliographic standards and/or MARC. From this analysis we propose a master attribute set that should be accounted for as BIBFRAME moves forward, and we take a quick look at which extant properties in BIBFRAME 1.0 map to elements of the master attribute set.

Content Standards Evaluation

The existing state of technical metadata expressed in bibliographic records has been driven largely by content standards that provide catalogers with the rules for metadata creation. By comparing the seven standards noted above to each other and mapping each specified technical attribute to a common generic attribute, we were able to develop a working list of forty-two generic attributes used by the bibliographic community currently to describe technical characteristics of physical and digital audiovisual resources.

Generic Attribute	Standards agree
carrier type	7
duration	7
base material	6
sound channel configuration	6
dimensions	6
extent[30]	6
media type[31]	6
playing speed	6
sound recording characteristic	6
tape track configuration	6
film sound configuration	6
recording medium	6
color content	6
sound content	6
file format	5
generation	5
groove characteristic	5
color space	5
projection characteristic/aperture	4
sound recording medium	4
video format	4
system requirements	4
broadcast standard	3
frame rate	3
aspect ratio	3
length	3
file size	2
frame size	2
polarity	2
noise reduction	2
bitrate	1
regional encoding	1
source type	1
level of compression	1
bit depth	1

[30] Extent is an element used in content standards that ultimately aggregates multiple attributes. We keep it on the list for now, but will likely recommend disaggregating such information into other attributes.
[31] FIAF combines the two concepts into a single attribute, recommending the omission of media type if it can be implied by the carrier type.

Generic Attribute	Standards agree
kind of color stock or print	**1**
kind of cutting (lateral, hill-and-dale)	**1**
sampling rate	**1**
source device	**1**
time start	**1**
video batch number	**1**
video line standard	**1**

Table 8. Generic attribute list as derived from an analysis of seven popular bibliographic content standards

Of this set of generic attributes, only two attributes are agreed upon by all seven standards. Twelve attributes are prescribed consistently by six of the standards, still a high percentage of agreement. Yet there are twelve attributes that are exclusive to only one of the standards.

Number of standards in agreement	Number of attributes agreed upon
7	2
6	12
5	4
4	4
3	4
2	4
1	12

Table 9. Attributes agreed upon by content standards

Such a quantitative analysis can be misleading, however, without a more granular approach. Each content standard embeds an element of scope or coverage to a given attribute. We see a common tendency in the content standards to express guidelines for documenting characteristics specifically for one media type (e.g., audio), ignoring the potential to document the same characteristics in other media types (e.g., video). For example, RDA supports the documentation of whether a sound recording is analog or digital in “manifest/item/sound characteristic/type of recording.” According to the rules of RDA, this is only applicable to the sound content of a given media resource, but it is of course possible (and desirable) that a video or a motion picture could equally be described as analog or digital. “Recording medium” is another similar example where RDA prescribes the need to document the recording medium for sound recordings as “magnetic” or “optical.” Again we might find the need to document similar information for video resources. While we recognize this discrepancy within the content standards, in our recommendations we make an effort to prescribe broader rather than narrower interpretations of the application of attributes to media types, with the goal of minimizing redundant attributes being used to document similar characteristics of differing formats (e.g., dimensions, length).

MARC Gap Analysis

Seven additional attributes are extant in MARC fields that are not overtly covered by any of the above standards.

Generic Attribute	Location in MARC
completeness	007-16 (m)
deterioration stage	007-15 (m)
file formats (#)	007-09 (e), 256a
film inspection date	007-17-22 (m)
location within medium	340h
materials applied to surface	340c
quality assurance targets (present?)	007-10 (e)

Table 10. Additional generic attributes covered in MARC but not covered in content standards. The full analysis is available in Appendix A.

Audiovisual-specific Metadata Standard Gap Analysis

As a next step, we compared the technical attribute guidelines of the evaluated content standards as well as those of MARC with AV format-specific standards from external communities. PBCore[32] and EBUCore[33] were selected as appropriate schemas for a comparative analysis. These are widely adopted audiovisual structural metadata and vocabulary standards, which have emerged out of the broadcasting communities in the U.S. and Europe, respectively. PBCore and EBUCore have been identified as particularly relevant for this study because their scope is limited to the description of audiovisual objects, regardless of workflow, method of creation, or intended use.

Because EBUCore has published a RDF ontology, one of our primary goals is to evaluate it as a potential external namespace for BIBFRAME to recommend for use in AV object profiles. Furthermore, at the time of writing, the PBCore community intends to adopt EBUCore's ontology rather than develop its own. Attributes unique to PBCore are currently being added to EBUCore.

There are several other schemas and standards that have been developed by the library, broadcast, distribution, and engineering communities that we do not consider in scope for the purposes of this study. Many were reviewed for their applicability, and determined to not be an appropriate point of comparison. Examples and rationale are as follows:

- videoMD[34] is a video-specific XML schema developed by the Library of Congress, originally in 2000-2003 as part of the AudioVisual Prototyping Project, and most recently revised in 2011. videoMD and its successor, reVTMD, are considered out of scope because they are specifically intended for physical to digital reformatting workflows. As a result of their intent, both contain distinct entity definition issues. For instance, the videoMD and reVTMD XSDs both contain

[32] More information is available from http://pbcore.org/.
[33] More information is available from https://tech.ebu.ch/MetadataEbuCore;jsessionid=3B49045C192B7756B25BC35983255292.
[34] More information, including the XSDs for both videoMD and audioMD, is available from: http://www.loc.gov/standards/amdvmd/audiovideoMDschemas.html.

elements for the description of physical objects, but as described in the documentation, these elements are only intended to be used for documentation of source objects whose signal or data migration resulted in the digital object that the XML document is describing. Therefore, the videoMD and reVTMD concept of physical or source media is incompatible with the BIBFRAME concept of Instance, making the potential comparison of attributes difficult.

- audioMD is a complimentary schema to videoMD and was developed at the same time. It was later superseded by AES-60, which in 2014 was merged with EBUCore. It is therefore considered redundant and obsolete for the purposes of this study.

- Entertainment industry metadata schema, including the Entertainment Identifier Registry (EIDR),[35] MovieLabs Common Metadata,[36] and DDEX[37] were reviewed. The scope of these is the digital supply chain, meaning that they are designed with production and distribution of intellectual property in mind. One of the key reasons these schema have not been included in the evaluation is that they do not deal extensively with the technical attributes of media objects.

- The W3C Ontology for Media Resources[38] was also evaluated. This resource was developed in order to, "to bridge the different descriptions of media resources, and provide a core set of descriptive properties." In addition to technical properties, the core set features properties for identification, creation, content description, rights, and more. We consider the technical properties defined here to be the minimal required properties for digital AV objects on the web, as noted in Section 2 above.

As part of our analysis, PBCore and EBUCore were cross-referenced with the guidelines of the library content standards and with the applicable MARC elements. This comparison allows us to:

1. Identify any additional technical attributes that are captured within external AV standards but are not currently applied in library cataloging practice;
2. Highlight technical attributes that are captured in the library world but not in the broadcast world, and discuss the implications therein; and
3. Identify and recommend potential attributes for inclusion in BIBFRAME, either through explicit definition of properties, or to recommend external namespaces for AV profiles.

Table 11 below provides a summary of the cross reference between the content standards reviewed, MARC, PBCore and EBUCore. Grey boxes indicate whether an attribute is present in a given standard. Note that this summary table identifies the presence of an attribute in ANY content standard reviewed.

[35] http://eidr.org/
[36] http://www.movielabs.com/md/md/
[37] http://www.ddex.net/
[38] http://www.w3.org/TR/mediaont-10/

Generic Attribute	Content Standards	MARC	PBCore	EBUCore
carrier type				
duration				
sound channel configuration				
media type				
file format*				
video format				
frame rate				
aspect ratio				
file size				
frame size				
bitrate				
bit depth				
sampling rate				
time start				
dimensions				
playing speed				
color content				
generation				
broadcast standard				
sound recording characteristic				
base material				
extent				
tape track configuration				
film sound configuration				
recording method				
sound content				
groove characteristic				
color space				
projection characteristic/aperture				
sound recording medium				
system requirements				
polarity				
regional encoding				
source type				
level of compression				

Generic Attribute	Content Standards	MARC	PBCore	EBUCore
kind of color stock or print				
kind of cutting (lateral, hill-and-dale)				
length				
noise reduction				
source device				
video batch number				
video line standard				
completeness				
deterioration stage				
file formats (#)				
film inspection date				
location within medium				
materials applied to surface				
quality assurance targets (present)				
number and type of tracks				
encoding format*				
captioning				
subtitling				
ancillary data				
alternative modes				
codec				
scanning format				

Table 11. Comparison of combined bibliographic content standards, MARC, PBCore, EBUCore, and WC3 handling of technical audiovisual attributes. Full analysis available in Appendix A.

** Note that file format and encoding format are not equivalent for file-based audiovisual resources. File format describes the container, or wrapper format, commonly expressed through its extension (e.g. QuickTime or .mov). Encoding format is a repeatable value (depending on the number and type of tracks present) that is used to describe the encoding of the individual video, audio, or other tracks contained within a file (e.g. h.264, PCM).*

This comparison reveals several notable alignments and gaps. First, there is relatively strong agreement between the content standards and MARC in the sense that most of the recommended descriptors identified in the content standards have corresponding elements in MARC where those values can be stored. For gap areas highlighted between these two columns, it is assumed that descriptors identified by some very specific content standards, such as the FIAF Cataloging Guidelines, would likely be handled by the MARC 300 field or a general note field.

There is also a good deal of agreement between PBCore and EBUCore. It is evident that these two standards are strong in technical attributes applicable to digital objects (e.g., bitrate) as well as those

that span both physical and digital objects (e.g., frame rate, aspect ratio). They are more limited in attributes specific to physical objects.

The gaps between EBUCore and PBCore and the library standards are fairly obvious from this table; many of those not supported by either are attributes for physical media. As libraries still hold and make available a large number of physical AV objects, there is a need for description of these holdings. This is in contrast to the broadcast community, which has been more aggressive in its efforts to reformat physical holdings, both because of the obsolescence of those media, but also because the users of broadcast archives are now typically best served by content in digital form.

Recommendations

Our findings reveal a broad universe of technical attributes for audiovisual resources (physical and file-based). From this broad attribute set, and based on our experiences with audiovisual resources in library, archive, broadcast, and other settings, we propose the following set of attributes that should be available to catalogers within the BIBFRAME context (further explored in Appendices B and C). Our selection focused heavily on an assessment of bibliographic needs (discovery, use, curation), using the following criteria to document the usefulness of a given attribute:

- *wide use*: the attribute is present in more than 100,000 existing MARC records
- *in use*: the attribute is present in less than 100,000 existing MARC records
- *search*: the attribute supports discoverability of the resource in distinguishing it from other resources
- *usability*: the attribute provides information to the user that may affect selection of the resource for use
- *retrieval*: the attribute provides information to the holding institution that supports identification and affirmation that the appropriate resource has been retrieved for the requester
- *playback*: the attribute provides information necessary to configure appropriate reproduction of the resource for a user
- *availability*: the attribute provides information that may support knowledge by a librarian whether or not the resource can be served to the requester
- *data specificity*: the attribute is recommended to support added data specificity for future computing needs

In order to arrive at this proposed set of attributes, we removed attributes from the master list above that either were too technical to be useful in a bibliographic environment, e.g., video batch number, or were specific to preservation use cases, e.g., system requirements[39]. We also suggest methods to disaggregate data from one attribute into sub-attributes, e.g., dimensions → length, width, diameter; bit depth → image bit depth and audio bit depth; and encoding format → audio encoding format and video encoding format. In two cases we propose enlargement of the scope of an attribute to make them

[39] We do see system requirements as useful information in some bibliographic use cases (e.g. a hypertext novel from 1993), but similar to the issue of events recorded in the MARC 583 field, we feel this requires broader discussion and input from the library community. For audiovisual resources, system requirements, beyond what can be gathered by the technical attributes recommended here, are largely for preservation purposes.

applicable to all resources types, i.e., type of recording → recording medium, video format → format. We also suggest the addition of two attributes that are not featured in any of the evaluated standards: chroma subsampling and mime type. We recognize that content standards cannot be changed because of this report, yet we hope that an improvement of BIBFRAME vocabularies and their definitions will support the content standards while simultaneously providing efficient attribute development for future BIBFRAME users.

Table 12 below presents the summary of technical attributes we recommend BIBFRAME provide some mechanism to support. For each attribute listed, we define the media type to which the attribute should be applicable. Additionally, we document how the existing BIBFRAME 1.0 vocabulary supports a small percentage of these proposed attributes.

Generic Attribute	F-P	F-F	V-PA	V-PD	V-F	S-PA	S-PD	S-F	BIBFRAME 1.0 Vocabulary
media type	x	x	x	x	x	x	x	x	bf:mediaCategory
carrier type	x	x	x	x	x	x	x	x	bf:carrierCategory
extent	x	x	x	x	x	x	x	x	bf:extent
dimensions	x		x	x		x	x		bf:dimensions
-- width	x		x	x		x	x		
-- length	x		x			x			
-- diameter	x		x			x			
base material	x		x	x		x	x		
generation	x	x	x	x	x	x	x	x	
polarity	x								
type of resource	x	x	x	x	x	x	x	x	
sound recording medium	x					x	x		
playing speed			x			x			
groove characteristic						x			
film sound configuration	x								
tape track configuration						x			
sound channel configuration	x	x	x	x	x	x	x	x	
sound recording characteristic	x					x	x		
projection characteristic	x	x	x	x	x				
frame rate	x	x	x	x	x				
format	x	x	x	x	x	x	x	x	bf:format
mime type		x			x			x	bf:format
broadcast standard			x	x	x				
file size		x			x			x	
frame size		x			x				
-- frame width		x			x				

Generic Attribute	F-P	F-F	V-PA	V-PD	V-F	S-PA	S-PD	S-F	BIBFRAME 1.0 Vocabulary
-- frame height		x			x				
regional encoding				x					
bitrate		x		x	x		x	x	
duration	x	x	x	x	x	x	x	x	bf:duration
sound content	x	x	x	x	x				bf:soundContent
color content	x	x	x	x	x				bf:colorContent
colorspace	x	x	x	x	x				
aspect ratio	x	x	x	x	x				bf:aspectRatio
time start			x	x	x	x	x	x	
has captioning	x	x	x	x	x				
has subtitling	x	x	x	x	x				
sampling rate				x	x		x	x	
image bit depth	x				x				
audio bit depth		x			x		x	x	
video encoding format		x		x	x				
audio encoding format		x		x	x		x	x	
scanning format			x	x	x				
chroma subsampling		x			x				

Table 12. Proposed audiovisual technical attributes that should be supported in the context of BIBFRAME. Full analysis available in Appendix C.

For scenarios where an attribute could apply to parts of a complex resource, e.g., audio bit rate of a file-based video resource, we opted to focus on the primary characteristic of the given resource. For a file-based video file, we do not recommend that bit rate should be used to describe the audio bit rate, only the overall bit rate of the video resource. In a preservation environment, one would need to know this information; however, in the context of BIBFRAME, we feel it complicates description and discoverability. If such detail is required by an organization, we assume such information would be managed outside of the BIBFRAME environment, either in a preservation system or in an audiovisual-specific production or collection management system.

Based on the findings of this report and our specific recommendations above, the question to be answered is how should BIBFRAME proceed in terms of providing properties for these technical attributes for audiovisual resources. We are aware that those responsible for the development of BIBFRAME would like to be able to look to an existing audiovisual RDF ontology to support these attributes. However, based on the findings documented in **Appendix C,** it is clear that no existing RDF ontology supports the full range of attributes that we feel should be supported by BIBFRAME. EBUCore supports many of the digital file characteristics needed to describe audiovisual resources, but stops short on the existing technical characteristics of physical resources. Schema.org is similar to EBUCore but leans even further towards light description of AV content for the web. Although weak in digital characteristics, the RDA RDF Vocabulary supports by far the most of our recommended technical attributes.

Given the current state of existing vocabularies, the following possibilities exist for future development:

- **Scenario 1**: Extend BIBFRAME to support the expression of all recommended attributes
- **Scenario 2**: Extend BIBFRAME to support the expression of all recommended attributes that are not already supported by EBUCore's, Schema.org's, or RDA's RDF ontologies (in that order or preference)

Scenario 1 is favorable as it enables BIBFRAME to embrace all aspects of AV material as needed by libraries for discovery and use. This simplifies the description of AV material and maintenance of the BIBFRAME vocabulary during what may be a long term of semantic development in information exchange.[40] However, as a negative consequence, it contributes to the proliferation of properties within the BIBFRAME namespace. Audiovisual resources are not the only types of content described in BIBFRAME. Such a decision would logically suggest similar extensions for other types of content, which would contribute to the further proliferation of properties. A possible solution would be to consider establishing an AV extension to BIBFRAME.

In Scenario 2, BIBFRAME maintains a smaller property set to manage within the namespace. However, as BIBFRAME evolves and as EBUCore, Schema.org, and RDA evolve, BIBFRAME will be beholden to the decisions of these external standards. If gaps emerge, BIBFRAME will have difficulty working with external groups to resolve the gaps. Note that in order to apply certain properties to a broad range of media types, either multi-domain and ranges will be need to be defined or fewer restrictions should be placed on the use of Instance properties. Properties assigned to the domain bf:Instance will have more flexibility across media types. As we have shown there are cases today where a property as defined is intended to be used in a specific way (e.g., rdam:typeOfRecording as a sub-property of rdam:soundCharacterisitic would lead a reasoner to conclude that the statement ex:ResourceA rdam:typeOfRecording rda:digital implies that the digital recording only applies to the sound aspect of ResourceA, not to the entire resource. As Coyle, et al demonstrate, "Heavily specified vocabularies carry costs to users downstream, both to consumers of RDF data created using the vocabulary and to creators who want to use a vocabulary in their own data, because deviations from the specification will be flagged by a reasoner as errors of logic. This can result in a siloed data set that will not play well with other data sources on the open Web."[41]

We include three examples with this report, expressing full sets of the proposed technical attributes for video, audio, and film resources respectively. **Appendices E, F,** and **G** serve as test case examples following the recommendations of Scenario 2 above.

[40] See question 6 in BIBFRAME's FAQs: http://www.loc.gov/bibframe/faqs/.

[41] Thomas Baker, Karen Coyle, and Sean Petiya, "Multi-Entity Models of Resource Description in the Semantic Web: A comparison of FRBR, RDA and BIBFRAME," Library Hi Tech, v. 32, n. 4, 2014 pp 562-582 DOI:10.1108/LHT-08-2014-0081. Available from http://kcoyle.net/LHTv32n4preprint.pdf, p. 14.

It will be important for members of the BIBFRAME working group, following this report, to determine the appropriate path forward.[42]

Annotated List of Appendices

Appendix A: Technical Metadata Gap Analysis

http://www.loc.gov/bibframe/docs/pdf/av-appendix-a.pdf

For the purposes of this study, we examined both generally applicable and widely adopted standards as well as more specialized AV description standards, as follows:

- Resource Description and Access (RDA)
- Anglo-American Cataloging Rules version 2 (AACR2)
- International Standard Bibliographic Description (ISBD)
- Archival Moving Image Materials: A Cataloging Manual (AMIM)
- International Association of Sound and Audiovisual Archives Cataloging Rules (IASA)
- Music Library Association Best Practices for Music Cataloging (MLA)
- International Federation of Film Archives Cataloging Manual (FIAF), November 2014 draft

Our approach in analyzing these content standards was to look specifically at the technical attributes that they recommend for audiovisual materials, and create a logical mapping across them. This mapping is fully expressed in Appendix A. Each colored set of columns represents a specific standard from the list above. Column A represents our attempt to label generic technical attributes that each standard attempts to describe. Columns CH, CI, CJ, and CK represent locations in examined structural standards (MARC, PBCore, EBUCore, and BIBFRAME) where each generic technical attribute is currently mapped. Rows where the text is grayed-out and italicized represent technical attributes that we determined to be out of scope for consideration in the BIBFRAME vocabulary.

Appendix B: AV Attribute Evaluation and Recommendations

http://www.loc.gov/bibframe/docs/pdf/av-appendix-b.pdf

Appendix B represents a full set of technical attributes for audiovisual resources that we encountered during this study. This list was culled to generate the recommended list of attributes in Appendix C. Columns C and D attempt to document the priority for mapping the data out of MARC and the frequency of current usage in MARC records (when the data is available). Column E notes whether we selected the attribute to be in or out of scope for BIBFRAME, and Column F notes our rationale for inclusion (e.g., wide use, choice by end users, playback, data specificity, or retrieval). Rows that are grayed-out and italicized were not selected to be in scope for inclusion in the BIBFRAME vocabulary.

Appendix C: Proposed AV Attributes for BIBFRAME

http://www.loc.gov/bibframe/docs/pdf/av-appendix-c.pdf

This appendix presents a recommended set of technical attributes for audiovisual materials that we feel BIBFRAME should support, either through the definition of applicable properties and classes within the BIBFRAME namespace, or through recommendation of properties from external namespaces. Rows represent technical attributes. Columns B and C provide suggested usage of each (if different from

[42] Once potential approaches are selected, there will be a need to test inference modeling with sample data to determine whether the solution is compatible, especially with the application of properties across media types. While properties from other vocabularies may have valid use, the inference rules defined by the ontologies need to be considered and tested.

standard usage found in existing content and structure standards). Columns D-K document the applicability of the technical attribute to specific media types (film physical, film file, video physical analog, video physical digital, video file, sound physical analog, sound physical digital, sound file). Columns L, M, N, and O document existing support for these attributes in RDF vocabularies in BIBFRAME 1.0, EBUCore, Schema.org, and RDA respectively. Column P suggests existing controlled vocabularies for the technical attribute, including the applicable namespace. Additional notes and caveats in Column R should be reviewed.

Appendix D: MARC 007 - 300 AV Field Comparison

http://www.loc.gov/bibframe/docs/pdf/av-appendix-d.pdf

There is a wide overlap between the types of technical metadata that can be stored in 007 fixed fields and 3xx descriptive fields. Not only is there overlap, but also certain fields can only be applied to resources of a certain type (e.g., Electronic Resources, Sound, Film, and Video), a byproduct of which is that different fields can be used to describe the same technical characteristic but for different resource types. For example, dimensions of recorded sound media are denoted in 007(06) and 007(07) as Dimensions and Tape Width, respectively (the available values of these two fixed fields combine to cover the standard possibilities of audio tape width); but for motion pictures and videorecordings, the same information must be noted only in 007(07) as Dimensions. The dimensions of all three resource types can also be described in both 340b and/or 300c. A detailed matrix of these relationships is available in Appendix D. After deduplication, there are 47 total fields[43] in MARC that support the expression of audiovisual or digital technical metadata.

Columns A and B document available attributes in the 007 fixed fields; Columns G, H, and I document available attributes in 3xx descriptive fields. Columns C, D, E, and F use the current MARC resource categorization (Electronic Resource, Motion Picture, Sound Recording, and Videorecording) to illustrate the applicability of a given attribute to a resource category. When the field is blue, it is only found in the 007 fixed fields. When the value is red, it is only found in the 3xx descriptive fields. When the value is purple, it is found in both.

Appendix E: Example Video Resources

http://www.loc.gov/bibframe/docs/pdf/bf-avtechstudy-app-e.pdf

This set of examples expresses a full set of the proposed technical attributes for video resources, including video-physical analog, video-physical digital, and video file resources.

The resources featured in this scenario are three instances of the work *Blade Runner* (Resource1). Resource2 is a 1981 VHS distribution copy of the work. Resource3 is an MXF-wrapped JPEG2000 file generated by the institution holding the VHS for preservation purposes. Resource4 is a 2008 DVD distribution copy of the work, acquired by the institution after the creation of Resource3.

Appendix F: Example Audio Resources

http://www.loc.gov/bibframe/docs/pdf/bf-avtechstudy-app-f.pdf

This set of examples expresses a full set of the proposed technical attributes for audio resources, including audio-physical analog, audio-physical digital, and audio file resources.

[43] This figure does not include the usage of 5xx generic note fields.

The resources featured in this scenario are three instances of the work *Mo' Roots* by Taj Mahal (Resource5). Resource6 is the 1974 LP release of the work. Resource7 is the 2008 CD release of the work. Resource8 is a preservation master of the CD release (a WAV audio file), generated by the holding institution in order to create onsite digital access copies of the resource.

Appendix G: Example Film Resources

http://www.loc.gov/bibframe/docs/pdf/bf-avtechstudy-app-g.pdf

This set of examples expresses a full set of the proposed technical attributes for film resources, including film-physical and film-file resources.

The resources featured in this scenario are two instances of the work *Gone With the Wind* (Resource9). Resource10 is a positive distribution print of the 1954 release of the film. In 2014, the institution holding the print scanned the film for preservation purposes, creating a DPX object (Resource11).

Resources

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