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Control or Chaos: Embracing Change and Harnessing Innovation in an Ecosystem of Shared Bibliographic Data

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ABSTRACT

With the transition from MARC to linked data, how we create and manage bibliographic data is drastically changing. This shift provides increased opportunity to test resource description theory and develop best practices. However, efforts to simultaneously define models for creating native linked data descriptions and crosswalk these models with MARC have resulted in ontological differences between implementers and unique extensions. From the outside looking in this progress may look more like bibliographic chaos than control. This apparent chaos, and the associated experimentation is important for communities to chart a path forward, but also points to a challenge ahead. Ultimately this disparate community innovation must be harnessed and consolidated so that open standards development supports the interoperability of library data. This paper will focus on modelling differences between RDA and BIBFRAME, recent attempts at MARC to BIBFRAME conversion, and work on BIBFRAME application profiles, in an attempt to define shared purpose and common ground in the manifestation of real world data. Emphasis will be placed on the balance between core standards (RDA, MARC, BIBFRAME) and community based extensions and practice (LC, PCC, LD4P, Share-VDE), and the need for a feedback loop from one to the other.

KEYWORDS

BIBFRAME; Bibliographic control; Cataloguing; Linked data; Metadata; Resource Description and Access.

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Introduction: What we will cover

This paper follows closely from the proceedings of the matching presentation at the *International Conference on Bibliographic Control in the Digital Ecosystem* (Bigelow and Sparling 2021). Our goal is to share findings from research and work towards implementation of BIBFRAME, with a particular focus on data exchange and interoperability. Findings are presented with the hope of informing next steps for the cataloguing and metadata standards communities to move forward with core standards supporting bibliographic control in emergent metadata ecosystems.
In an effort to capture some of the challenges for bibliographic control emerging in the changing landscape for library bibliographic metadata we will focus on several key areas of discussion as they relate to data reuse: the intersection of RDA and BIBFRAME; the complexities of historical MARC data through conversion; what standard BIBFRAME and BIBFRAME infrastructure should look like; and in this context how we can harness innovation and maintain control.

Context: Our lens

In 2018 strategic planning at the University of Alberta Library (UAL) resulted in a plan for *Moving Forward with Linked Data* which stated that "In order to reap the benefits of full participation in the linked open data environment, UAL should continue to take steps towards complete conversion of existing library data to linked open data" (Farnel et al. 2018, 8). Since the plan's publication, UAL has continued as a member of the Share Virtual Discovery Environment (Share-VDE) and actively engaged in the Linked Data for Production Phase 2 (LD4P2) as a cohort library. We are also a member of the Program for Cooperative Cataloging (PCC). Much of this paper is informed by experiences and observations as a member of these projects and initiatives.
As such, it is worth noting from the outset that this paper will focus on bibliographic control in a BIBFRAME context. This is in line with decisions at the UAL for transitioning our MARC data to a linked data ecosystem, but also in line with our commitment to the PCC. We fully recognize, however, that PCC does not represent all libraries and that BIBFRAME is just a piece of a larger linked data framework. While much of what we will discuss may have applications for interchange of linked data for libraries as a whole, we have purposely scoped the discussion to BIBFRAME.

Experimentation to Implementation

Leading up to 2018, analysis of conversion from MARC to BIBFRAME was undertaken at UAL (Bigelow et al. 2018). This analysis highlighted that conversion processes captured RDA core elements and were generally functional. Issues were noted however, many of which related to accounting for changes in cataloguing standards over time, and in choices made for mapping MARC to BIBFRAME. We ended the article with a note that "Waiting until we have no choice to transition will not foster the desired community collaboration around BIBFRAME development or support a smooth implementation" (15).
Since 2018, UAL has changed its focus from research and analysis to working towards BIBFRAME implementation. Through work with the LD4P2 Cohort, PCC, and Share-VDE, significant effort

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has been put into staff training as well as further refinement of conversion processes, data modelling, and application profiles. BIBFRAME implementation is a large-scale ongoing process that requires revision of our workflows and technical ecosystems to support a hybrid MARC and BIBFRAME environment. As we have undergone this work the importance of replacing workflows for metadata reuse has become top of mind.

Developing workflows for sharing BIBFRAME data presents certain challenges. Testing metadata reuse requires both supporting systems and data sets to share. Now, however, along with the Library of Congress (LC) there are other national libraries (Axelsson 2018; Lendvay 2020) working on BIBFRAME implementation, and numerous other libraries contributing to projects like LD4P (Stanford Libraries 2018) and Share-VDE (Lionetti 2021) such that there are billions of quads of data live in BIBFRAME (Share-VDE 2019). As we know, "Universal Bibliographic Control is grounded on sharing the effort of resource description, eliminating redundancy by encouraging sharing and re-use of bibliographic data" (IFLA 2017). We need to make sure that BIBFRAME data can support interchange. To achieve bibliographic control there needs to be agreement on what standard BIBFRAME looks like.

Interchange with MARC certainly is not perfect. Different communities of practice apply different standards and different MARC formats, quality varies, and the copying of records to local silos duplicates effort. At the same time, systems and practices for working with MARC are so long established that we often take interchange for granted.

Bringing it all together

Beyond the challenges of working with new standards in a linked data environment, the scale of change away from MARC necessitates fairly long term hybrid environments with compounding complexity. Figure 1 is provided as an example, capturing the plans at UAL for linked data implementation.

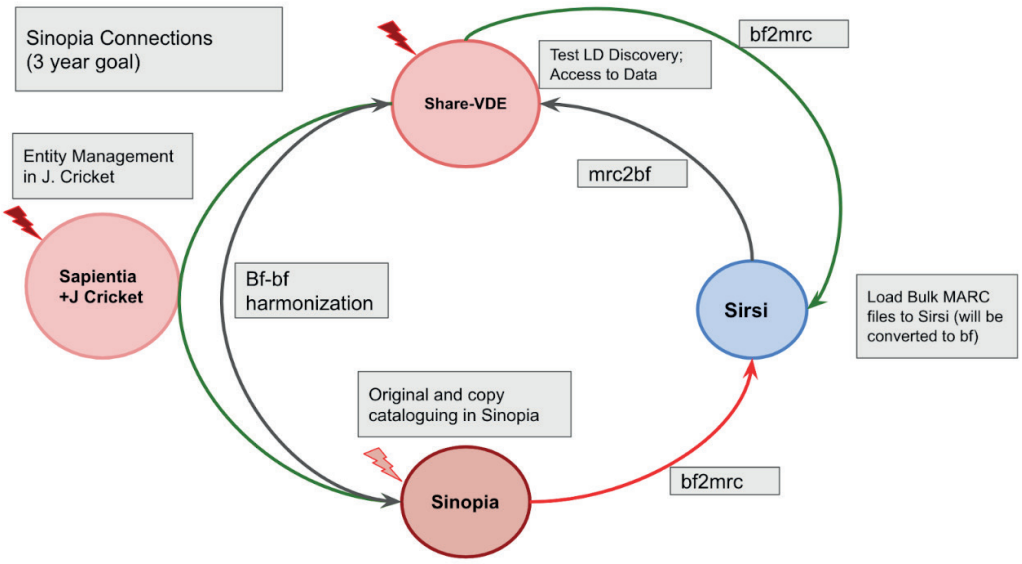

Fig. 1. Sinopia Connections (3 year goal) (Image by Bigelow, 2020)

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While some library systems are beginning to adapt for BIBFRAME, the complexity highlighted in Figure 1 is obvious. Making this kind of transition involves significant adaptation and/or system migration. The scale of such a transition means that not all libraries will be moving from MARC to BIBFRAME at once, necessitating support for hybrid systems for some time. In the case of UAL, current use of SirsiDynix Symphony means that for a number of library services we will still need MARC until a more complete transition is achieved. Moreover, even when we are able to fully transition our own systems, we need to consider the reliance of libraries generally on shared bibliographic data.

As outlined in Figure 1, to work in BIBFRAME we need a cataloguing editor with standardized application profiles with comprehensive coverage to describe a range of resources in BIBFRAME, but we also need conversion and data flow processes established for converting from MARC to BIBFRAME and from BIBFRAME to MARC. One might easily wonder where the problem lies here. After all, multiple MARC to BIBFRAME conversion processes have been established (LC, Share-VDE, LibrisXL, ExLibris), we have the LC BIBFRAME to MARC converter, and both the LC and Sinopia BIBFRAME cataloguing editors. That the library community is now at a point where we have working tools to start putting together a BIBFRAME ecosystem like this is an incredible achievement. On the other hand though, to bridge from individual and project-specific toolings to a functional ecosystem means that they all need to work together, and, given the reliance on shared data in libraries, they don't just need to work together for one institution, but internationally.

With the shift away from MARC for bibliographic description, for the purpose of interchange we are left with two relatively new standards (RDA and BIBFRAME). The combination of these standards is emergent and adds additional complexity to ensuring bibliographic control in a BIBFRAME environment. For the remainder of this paper we will focus on RDA, BIBFRAME and related aspects pertinent to bibliographic control by examining our experiences with LD4P2 and Share-VDE.

RDA and BIBFRAME: Chaos and convergence

To begin wading through the chaotic divide between RDA and BIBFRAME we need to take a trip into the past and the initial release for both standards.

From the very outset of RDA in 2010 there was agreement that an alternative to MARC was required to support the extent of RDA (Cronin 2011; McGrath 2011; Samples 2011). Though MARC has continued to evolve since then, we have now had 10 years where the theoretical underpinnings of RDA have been largely untested by practice. Despite the predominant stasis in encoding standard, RDA has continued to evolve to the point that we have an entirely new version of RDA as of December 2020 (RDA Steering Committee 2020).

BIBFRAME has also had a long development trajectory, beginning in 2011 with the goal of creating a community standard to allow RDA to move beyond MARC. We would argue however, that work on BIBFRAME didn't accelerate with the wider library community until 2017 when LC released conversion tools and specifications for testing. Along the same approximate timeline, early implementation cases for BIBFRAME emerged (Library of Congress, n.d.a), and large scale proj-

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ects like LD4P and Share-VDE meant that data and tools in production allowed for development of best practices and testing of theories dating back to when FRBR was initially released in 1998 (Samples and Bigelow 2020; IFLA Study Group on the Functional Requirements for Bibliographic Records, and Standing Committee of the IFLA Section on Cataloguing 1998).

Reflecting on this timeline, 2017-2020 saw increased development not just in BIBFRAME, but in the evaluation, testing and analysis of use of RDA in a linked data environment. This acceleration has resulted in beautiful chaos, with further work on data modelling, more maturity in conversion processes, and use case development driving novel extensions and adaptations. There are a number of excellent articles analyzing how well BIBFRAME can accommodate RDA and associated challenges (Zapounidou, Sfakakis, and Papatheodorou 2019; Taniguchi 2017; Baker, Coyle, and Petiya 2014; Guerrini and Possemato 2016; Seikel and Steele 2020; Taniguchi 2018; El-Sherbini 2018; Zapounidou 2020), and while this is an important question, it is not the only one. With the relative maturity of both standards, and the ability to work with data in live systems, both can now be tested and adjusted to best meet user needs. The question becomes, what does an application profile utilizing RDA and BIBFRAME look like in the real world, and how does it and the data model evolve under the scrutiny of use for resource description and from user feedback?

With the RDA 3R project and the new toolkit, changes to RDA are significant enough that the PCC chose to postpone implementation until at least July 2022 (Program for Cooperative Cataloging Policy Committee 2020). In part this was based on the need for further work on policy statements and metadata documentation, but there was also a recognition that a test is warranted for both application in MARC and BIBFRAME (Ibid.). In 2010 a test was carried out on the application of RDA in MARC, so with the development of BIBFRAME we are only now getting to a point where these many components can come together. As noted in *Exploring Methods for Linked Data Model Evaluation in Practice*, "A final identified way of assessing an ontology involves testing the data itself throughout the modeling process. This could take the form of checking against use cases and competency questions, and user testing of the data in the application" (Desmeules, Turp, and Senior 2020, 68). With implementation cases such as the National Library of Sweden and projects like Share-VDE and LD4P this kind of assessment can finally happen for both BIBFRAME and the use of RDA as a cataloguing content standard with it.

Analysing native BIBFRAME and the use of RDA

Working on the creation of application profiles for the Sinopia cataloguing editor has provided an excellent opportunity to test the application of RDA in BIBFRAME. For this analysis in Sinopia it is worth providing the context that UAL, along with all members of LD4P2 were PCC institutions. While LC application profiles were used as a starting point, Sinopia development then allowed for the creation of base application profiles for all users, and experimentation/localization such that each member could create application profiles of their own. This flexibility continues to be a strength, allowing for ongoing development of core/base application profiles while allowing for testing of new concepts.

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Through the course of work on UAL Sinopia application profiles, decisions on the use of properties needed to be made. In constructing application profiles, thought was given to PCC standards and ensuring that core elements were captured for resource description. While the Sinopia application profiles used for analysis here are UAL specific, they were created in collaboration with LD4P2, the Profiles Affinity Group and with a thought to ongoing work with PCC. The example shown in Figure 2 is an extract of the JSON from the UAL Monographs profile in Sinopia, adjusted into a spreadsheet. Figure 2 presents the property list and labels, the corresponding RDA instruction/entry note, while also reflecting recent modelling updates from Share-VDE.

Resource Template Label	Type	Mandatory	Repeatable	PropertyURI	PropertyLabel	RDA Instruction/Entry Note
UAL Monograph Work (Un-Nested)	resource	false	true	http://id.loc.gov/ontologies/bibframe/expressionOf	Has Opus	
	resource	false	true	http://id.loc.gov/ontologies/bibframe/hasInstance	Has Instance	
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/identifiedBy	Work Identifier	Used with Unspecified
	resource	false	true	http://id.loc.gov/ontologies/bibframe/contribution	Contribution (Creator/Contributor)	
	resource	true	true	http://id.loc.gov/ontologies/bibframe/title	Title Information	
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/genreForm	Form of Work	http://access.rdatoolkit.org/6.3.html
	literal	false	true	http://id.loc.gov/ontologies/bibframe/originDate	Date of Work	http://access.rdatoolkit.org/6.4.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/originPlace	Place of Origin of the Work	http://access.rdatoolkit.org/6.5.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/geographicCoverage	(Geographic) Coverage of the Content	http://access.rdatoolkit.org/7.3.html
	literal	false	true	http://id.loc.gov/ontologies/bibframe/temporalCoverage	(Time) Coverage of the Content	http://access.rdatoolkit.org/7.3.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/intendedAudience	Intended Audience	access.rdatoolkit.org/7.7.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/hasSeries	In Series	URI for series as a work
	resource	false	true	http://id.loc.gov/ontologies/bibframe/note	Notes about the Work	
	resource	false	true	http://id.loc.gov/ontologies/bibframe/dissertation	Dissertation	http://access.rdatoolkit.org/7.9.html
	resource	false	true	http://id.loc.gov/ontologies/bibframe/tableOfContents	Contents	
	resource	false	true	http://id.loc.gov/ontologies/bibframe/summary	Summary	http://access.rdatoolkit.org/7.10.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/subject	Subject of the Work	http://access.rdatoolkit.org/rdachp23_rda23-12.html
	resource	false	true	http://id.loc.gov/ontologies/bibframe/classification	Classification numbers	
	lookup	true	true	http://id.loc.gov/ontologies/bibframe/content	Content Type	http://access.rdatoolkit.org/6.9.html
	resource	false	true	http://id.loc.gov/ontologies/bibframe/language	Language of Expression	http://access.rdatoolkit.org/6.11.html
	resource	false	true	http://id.loc.gov/ontologies/bibframe/notation	Script	http://access.rdatoolkit.org/7.13.2.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/illustrativeContent	Illustrative Content	http://access.rdatoolkit.org/7.15.html
	lookup	false	true	http://id.loc.gov/ontologies/bibframe/colorContent	Color Content	http://access.rdatoolkit.org/7.17.html
	resource	false	true	http://id.loc.gov/ontologies/bibframe/supplementaryContent	Supplementary Content	http://access.rdatoolkit.org/7.16.html
	resource	false	true	http://id.loc.gov/ontologies/bflc/relationship	Related Works	http://access.rdatoolkit.org/rdachp25_rda25-65.html
	resource	false	true	http://id.loc.gov/ontologies/bibframe/hasExpression	Related Expressions	http://access.rdatoolkit.org/rdachp26_rda26-25.html

Fig. 2. UAL Monographs profile extract. (Image by Bigelow and Sparling 2020)

Given the importance of RDA for PCC, past work was leveraged for the creation of UAL Continuing Resource and Monographs application profiles. In particular, the mappings from CSR (Balster, Rendall, and Shrader 2018) and BSR (BIBCO Mapping BSR to BIBFRAME 2.0 Group 2017) to BIBFRAME provided a quick reference to ensure that Sinopia application profiles captured key elements of description. This initial launch point was then informed by iterative phases of development and feedback with cataloguers at UAL and collaboration with others in LD4P2. The results are still a work in progress, but we now have functional application profiles that demonstrate an implementation scenario for RDA in linked data with BIBFRAME.

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The creation of a functioning linked data editor through LD4P2 was very impactful, so again it is important to ask what the problems are in terms of bibliographic control. Overall the challenges here are tied to the successes. As we have referred to beautiful chaos, necessary innovation to support linked data implementation, almost by definition must go beyond current infrastructure for standards development. With multiple concurrent projects and implementations and no single standards body guiding shared practice, slightly different approaches have emerged. On the other hand, theories and practices have been confirmed where multiple communities have come to the same conclusion based on independent analysis, as with the emergence of the svde:Opus and bflc:Hub in close comparison with the LRM Work.

Convergence: The Opus

One key difference between RDA and BIBFRAME that surfaces in much of the literature is the differentiation between core classes (RDA: Work/Expression/Manifestation/Item; BIBFRAME: Work/Instance/Item). In BIBFRAME the use of bf:hasExpression and bf:expressionOf helps solve this, but ultimately this ends up as a Work-Work relationship and the impact of which has been a matter of considerable discussion (Heuvelmann 2018). Happily, work in the Share-VDE community and at LC has attempted to address this discrepancy with BIBFRAME extensions.

In 2018 the Share-VDE Work ID Working Group (now called the Sapientia Entity Identification Working Group) was formed with the initial charge to review the creation of works and work identifiers for BIBFRAME data converted from MARC by Share-VDE. This in itself was a key project to support interchange by developing universal identifiers for works, but through the analysis of data sets from participating libraries the Working Group identified two key finding:

1. While Work → Expression relationships can currently be expressed in BIBFRAME, these are ultimately Work-Work relationships, and determining the initial or primary work, or hierarchical relationships between works may prove difficult with this structure.
2. Through conversion from MARC to BIBFRAME, or automatic work ID generation based on BIBFRAME elements, unless we can define a difference (a fingerprint for each cluster or constellation) between Work and SuperWork [renamed as Opus] elements then these relationships (work-expression) cannot be captured through conversion or automated processing. With the scale of data conversion underway, not doing this would seem like a missed opportunity. Once a separate fingerprint is defined for this primary work, it needs a name, thus the creation of SuperWork [Opus]. (Bigelow 2019)

Following these initial findings in 2018, the svde:Opus was developed in relation to the svde:Work based on iterative analysis of library collections converted from MARC to BIBFRAME and utilizing LRM and RDA elements as a guide. The model that surfaced (see Figure 3) with the svde:Opus as a type of bf:Work performs something of an ontological magic trick, preserving core elements and definitions for BIBFRAME for those that choose not to use the extension, but allowing for the benefits of the Opus and use with RDA.

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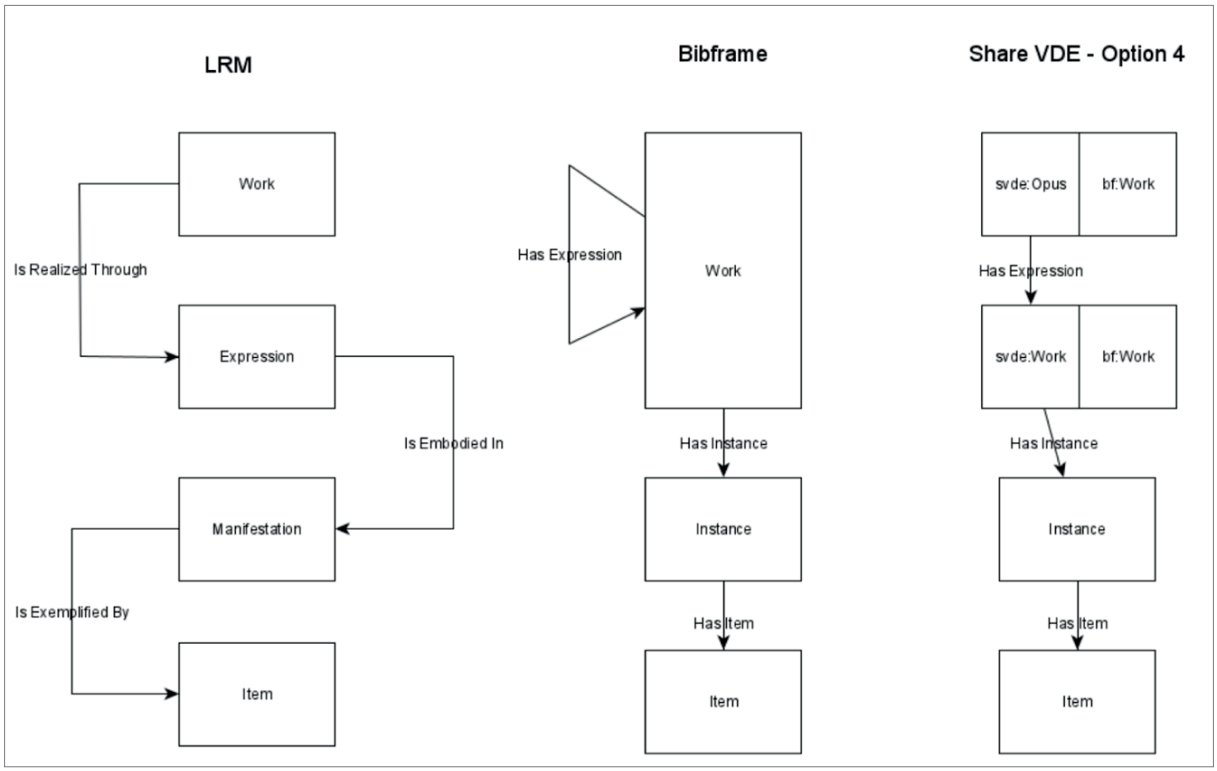

Fig. 3. LRM, BIBFRAME and Share-VDE model comparison. (Ford, Kevin 2020b. [Share-VDE - Option 4]. Created for the Share-VDE Sapientia Entity Identification Working Group)

It is worth emphasizing that the svde:Opus emerged as a result of large scale testing of real world data. This is a beautiful example of theory being proven by practice, while at the same time highlighting the nature of the collaborative work on the application of RDA in BIBFRAME.

In parallel with the svde:Opus, LC developed the bflc:Hub. In this the Hub was "Pursued because [they] realized [they] were trying to do too much with bf:Work" (Ford 2020a). In many ways LC's use case was very similar to the need for the Opus, further validating a general need for this level of description and work aggregation. At the same time though, the Hub was defined slightly differently, conceptualized to be "Intentionally brief. Intentionally abstracted. Designed to ensure they are lightweight and maximally (re)usable" (Ibid.). While the Opus and Hub are both exciting developments, how these extensions inform the development of BIBFRAME as a standard remains to be determined.

As Share-VDE data is available for reuse in Sinopia, UAL has incorporated the Opus into our application profiles for resource description, allowing this structure to be tested and immediately put into use by our cataloguers when adding new Instance or Work descriptions for an existing Share-VDE Opus. Further refinements to how the Opus is incorporated in our application profiles will likely be needed, but being able to work with it in a cataloguing editor has made this much more real and hopefully will inform development of more standard best practice as PCC data has been converted from MARC to BIBFRAME and is now hosted by Share-VDE (Picknally and Bigelow 2020).

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Conformance and questions

As captured by the Task Group on PCC Sinopia Application Profiles "It is well known that there is no official mapping between BIBFRAME and RDA. The closest we have are the LC profiles and the BSR – and CSR – to BIBFRAME spreadsheets from some years ago, but none of these is "official" (PCC Task Group on Sinopia Application Profiles 2020, 9). The creation of "official" mappings should be a high priority for the RDA Steering Committee (RSC) to support RDA implementation scenarios in BIBFRAME, yet for the time being their absence does not mean that the data does not work.

An important piece of this discussion about what "official" RDA is stems from differing opinions on what RDA needs to be for particular communities of practice. The PCC Position Statement on RDA in August 2019 indicated that

> It is important to remember that RDA and RDA/RDF are two different things. RDA instructions will always be more applicable to traditional library resources than to newly emerging material types. We might also consider that given one of our goals for linked data is to communicate and consume data from beyond libraries, our RDF serialization might need to be more approachable than the complexity of RDA/RDF. As such and because we will probably be in a long-term transition away from MARC, PCC will continue to treat RDA as a loose content standard and participate in RDA/RDF and BIBFRAME discussions to assess our ideal linked data output. (Program for Cooperative Cataloging Policy Committee 2019, 3)

This distinction is tied to further developments of RDA 3R where increasingly efforts appear to focus on shifting RDA from a content to an encoding standard with RDA/RDF. Keeping in mind the PCC community context for Sinopia development it should not be surprising that UAL application profiles approached RDA implementation with a focus on using it as a content standard. This does not preclude the use of RDA/RDF in UAL profiles, but instead means that it can be applied along with BIBFRAME properties as needed.

Further stressing the difference in definition, in May 2020 the RSC released a discussion paper on RDA Conformance, indicating the required use of RDA/RDF and RDA constrained elements. The paper outlined that "A metadata statement is either conformant with RDA or it is not; there is no utility in the concept of partial conformance of a statement" (Dunshire 2020, 3). This statement suggests a shift in approach for RDA away from being an encoding scheme agnostic content standard. Given that PCC is not using RDA/RDF in this way, it indicates that PCC data (in MARC or BIBFRAME) cannot be considered RDA conformant and thus not an implementation scenario.

Similarly, despite early concerns about the use of RDA constrained elements in a linked data environment, the 2020 discussion paper highlighted that "The unconstrained element set is not an integral part of RDA, and its use in metadata statements is not conformant with RDA" (Dunshire 2020, 2). In 2013 Alan Danskin captured the issue here well:

> An aspect of the linked data vision is that metadata can break down barriers, including those silos erected within the cultural heritage sector to meet the specific needs of museums, archives and libraries. Placing constraints on linked metadata elements is a barrier to reuse. For example, RDA Publisher's Name is an RDF property with domain manifestation. This is consistent with the FRBR model but it

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> makes the element unattractive to users or communities who do not perceive a need to distinguish between Work, Expression Manifestation and Item. It has taken some time for JSC [Joint Steering Committee] to understand these perspectives and from JSC's perspective an element set without FRBR cannot be RDA. (4)

It appears that since 2013 JSC has only become more firm in this siloed worldview. This is an unfortunate policy approach and strongly points to the need for further community collaboration on standards development. Nevertheless, as mappings are established between RDA constrained and unconstrained elements, ultimately what is important is semantic interoperability. If in order to implement RDA in BIBFRAME PCC or other communities of practice need to cease being conformant with RDA, so long as the resulting BIBFRAME data works for interchange the focus should be on further collaborative effort towards that end.

RDA/RDF or BIBFRAME

Reflecting back on Figure 1, the distinction between use of BIBFRAME versus RDA/RDF for encoding is an important one. If we end up with a large number of libraries using both then we will want to ensure interoperability and reuse of data between them. While RDA is certainly comparable to BIBFRAME, there are notable differences, for example with some elements having one to many or many to one relationship (McCallum and Williamschen 2019). Nevertheless, as demonstrated by work on Sinopia application profiles, core element sets can clearly be mapped and utilized from one to the other, and this should also support mappings for interchange, or indeed the use of both in a shared data set. Similarly, a Sinopia BIBFRAME application profile can readily incorporate both mappings to RDA instructions, and utilize RDA/RDF lookups when needed to utilize RDA vocabularies, just as Share-VDE has shown that RDA/RDF can be used to enrich BIBFRAME data (Hahn, Bigelow, and Possemato 2021).

The complexities of historical MARC data through conversion

While determining interactions between emergent library linked data standards are important for moving forward, we must also consider that as libraries move to BIBFRAME the majority of BIBFRAME descriptions will have started as MARC records. As such, some consistency is needed for the choices we make on how to convert MARC descriptions to BIBFRAME. Here we must consider where our data reflects both changes in practice as cataloguing standards have evolved, and where communities of practice have taken different approaches to resource description in MARC. As a result conversion processes from MARC to BIBFRAME face the challenge of accounting for myriad variations. Whether looking at the needs of an individual library, consortia, or library system, the changes in standards and local practices over time need to be addressed when converting to BIBFRAME. The work done by Share-VDE on MARC to BIBFRAME conversion is a prime example of this. Given membership from national and research libraries across North America and Europe, multiple languages and variations resulting from unique communities of practice need to be analysed and accounted for through conversion.

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One initial approach to work through this was to analyse the results of the conversion process by looking at converted records from 1985 and 2015 separately. Along with a more comprehensive analysis by Share-VDE members and Transformation Council, this assessment informed adjustments to the Share-VDE MARC to BIBFRAME conversion processes (Share-VDE Advisory Council 2018). It is important to note that handling some of these differences requires decisions, specific solutions, and sometimes compromises. An example of changing standards over time is the need to account for records with and without 33X fields (using GMD). Similarly, there have been different approaches across institutions and time for handling 7XX fields for related Opus, Work and Instance.

That many such variances need to be considered and decisions made for conversion, matching, and clustering again points to the desperate need for standardization, at least for core BIBFRAME elements. If these decisions are made independently for a given library or community for elements that are not solely local, then we are setting ourselves up for trouble as we begin sharing data (Park and Kipp 2019). Further, this speaks to the importance of transition planning. While MARC will need to be supported for some time to come, updates to it should be made with an awareness of the impact on multiple conversion processes.

Defining standard BIBFRAME data and infrastructure

Related to the issue noted above about decisions made for conversion from MARC to BIBFRAME, we also need to consider what the desired shape of BIBFRAME should be. It has been argued that "different interpretations derived from BIBFRAME's definitions, aiming to provide flexibility, may result in different implementations, hindering interoperability not just in mappings, but also between BIBFRAME implementations" (Zapounidou, Sfakakis, and Papatheodorou 2019, 301). To date we have encountered multiple examples of how different approaches to BIBFRAME modeling negatively impact data reuse. In order to support the transition from MARC to BIBFRAME and ensure data interoperability we require:

1. The data output of each MARC to BIBFRAME conversion process to be interoperable with the BIBFRAME created natively in RDF.
2. The ability to reuse BIBFRAME created in one community in other BIBFRAME stores.
3. BIBFRAME in various flavours to be converted to MARC with similar consistency.
4. New tools and processes to support various serializations of BIBFRAME (RDF XML, n-triples, n-quads, turtle, JSON-LD), or for the community to decide on which to use for development.

An example highlighting the need for points 1. and 2. is demonstrated through Sinopia copy cataloguing workflows. The Sinopia search feature allows users to search other sources for data reuse (currently BIBFRAME data created in Sinopia by other institutions and BIBFRAME data from the Share-VDE database). Figure 4 shows the results of a search for the UAL Share-VDE Work description of *Meditations*.

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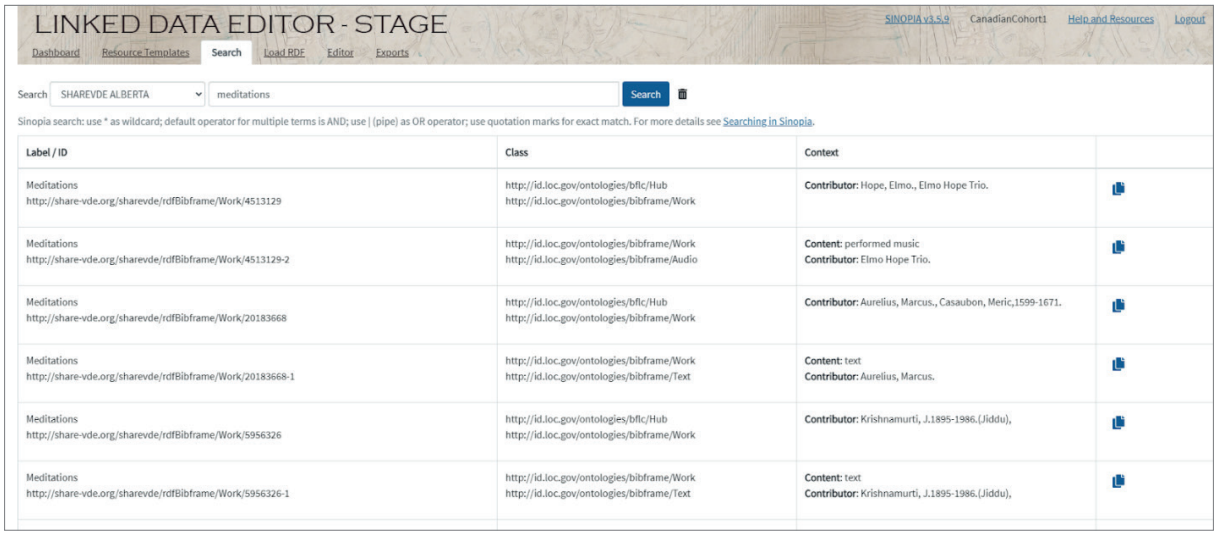

Fig. 4. Screenshot of a search for a UAL Share-VDE Work description in the Sinopia editor

Reuse of BIBFRAME data in this way is a critical requirement for implementation, yet, because of the different choices made through the development path of Sinopia application profiles for original cataloguing in BIBFRAME and Share-VDE (where thus far BIBFRAME has been solely created through the process of conversion from MARC) challenges arose when attempting to import Share-VDE descriptions into Sinopia application profiles. Figure 5 illustrates how a number of triples from the Share-VDE description were unable to be brought into the PCC monographic work application profile.

Fig. 5. Screenshot of unused triples following the import of a Share-VDE Work description into the Sinopia PCC Monographic Work application profile in the Sinopia editor

In this case work is underway to resolve inconsistencies through collaborative effort with LD4P3, Share-VDE and PCC, but as more implementation cases emerge for BIBFRAME it makes sense to save work down the line by ensuring standardization to enable this kind of data reuse. An interesting note here is the continued lack of clarity on LC BIBFRAME data reuse outside of LC. LC is a member of PCC, and though one of the goals of LD4P3 is the creation of a shared PCC BIBFRAME datapool, there is little to indicate how LC will be contributing native BIBFRAME

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descriptions. While standardized conversion from MARC does offer a pathway to consistent, reusable BIBFRAME data, the inability of native LC BIBFRAME to coincide with Share-VDE and Sinopia flavours of BIBFRAME supports the case for a swift standardization of a core BIBFRAME shape that works broadly for all libraries.

Addressing points 3. and 4. the case of conversion from BIBFRAME to MARC can be examined. In May 2020 LC released the XSLT for converting BIBFRAME to MARC along with associated conversion specifications (Library of Congress, n.d.b). Significant effort went into the MARC output, with LC knowing that MARC needed to be supported for many institutions for some time. As encouraging as this development is, in discussion on bibliographic control there are two challenges. The first issue is that BIBFRAME to MARC conversion output is dependent on the modeling choices and the resulting shape of the BIBFRAME that you start with. For example, you cannot successfully convert Sinopia BIBFRAME to MARC with the LC converter. This is a direct result of the differences in the Sinopia and LC application profiles which create different shapes of BIBFRAME. Similar inconsistencies in the shape of BIBFRAME and the impact on data interoperability are highlighted in the recently published *Final Report* of the PCC Task Group on Sinopia Application Profiles (2020). The second issue is that the LC converter only works with RDF/XML, while Sinopia uses JSON-LD and Share-VDE uses n-quads. These modelling differences and the need to utilize various serializations of RDF have the potential to encourage the development of new independent conversion processes which would add additional complexity when the goal is to standardize these processes.

Harnessing innovation and maintaining control

Throughout the course of BIBFRAME development and work across various communities on library linked data models, there have been calls for increased community engagement and the need for library linked data to be interoperable with data outside the library domain (Folsom 2020). As evidenced above though, it is equally pressing for real world library linked data to support interchange and interoperability between the institutions and projects creating, converting and publishing it. To do this there must be consensus on what constitutes standardized, core BIBFRAME data. To date, BIBFRAME development has been iterative, built initially by LC, but subsequently shaped by implementers through feedback provided to LC. Since the early days, LC has acknowledged that the BIBFRAME model,

> like MARC, must be able to accommodate any number of content models and specific implementations, but still enable data exchange between libraries. It needs to support new metadata rules and content standards that emerge, including the newest library content standard - RDA (Resource Description & Access). The BIBFRAME model must therefore both broaden and narrow the format universe for exchange of bibliographic data. (Miller et al. 2012, 5)

Community efforts and experimentation utilizing BIBFRAME have demonstrated its ability to broaden our universe. Experimentation has led to the creation of unique community extensions, format specific application profiles, and mappings between other emergent and project-specific library linked data models. It has also allowed us to work together as a library community, sup-

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ported by project partners, to begin building the systems and infrastructure we need to start converting, creating, editing, and making BIBFRAME data discoverable to our users. However, to support a working BIBFRAME data ecosystem, we now need to narrow our focus and define our core standards to support BIBFRAME interchange and conversion to maintain control across implementations. Moreover, the process of BIBFRAME implementation without exception requires a period where hybrid systems are in place (utilizing both BIBFRAME and MARC). This complex ecosystem requires standard practice more than we have ever needed it.

Experimentation and iterative development is a common characteristic of ontology building in LAM domains (Desmeules, Turp, and Senior 2020) and BIBFRAME is no exception. In fact, as noted, the BIBFRAME model's flexibility in implementation (Zapounidou, Sfakakis, and Papatheodorou 2019), while allowing for exploration and extensions across multiple communities, has led us to an impasse if we want to move ahead with wide implementation. With this knowledge, how do we move forward and define standards for BIBFRAME that support creation, reuse and conversion workflows? To do so we argue the following conditions need to be met:

1. Define core BIBFRAME elements necessary for resource description
   Defining core BIBFRAME elements is needed to facilitate the creation, reuse and conversion of BIBFRAME data between libraries. It is noteworthy, then, that PCC specific application profiles developed by the Task Group on PCC Sinopia Application Profiles were released alongside their final report in November 2020. The report outlines that

   > The intention of these templates is to provide a structured core of resource templates that allow catalogers to create PCC-level descriptions with uniform modeling and a basic set of vocabularies. It is hoped that they serve as the basis for a formal PCC standard (as an extension to the current BSR and CSR) at some point, and that in feeding the PCC data pool, serve as a pool of well-structured data to share, and provide vendors and developers data with which to experiment. (PCC Task Group on Sinopia Application Profiles 2020, 3)

   This is an excellent start towards standardization for the PCC community and hopefully it will extend to other communities and institutions. These application profiles support the identification of core BIBFRAME elements with attention to RDA implementation within them. They will also provide a template through which to test the resulting data. They will not, however, resolve the inconsistencies between the shape of BIBFRAME data being created and shared by other sources, such as Share-VDE and LC.

2. Define a standard BIBFRAME model and "shape" to support conversion and data reuse
   Data modelling assessment within the LAM domain has been shown to be an often ambiguous task (Desmeules, Turp, and Senior 2020). In particular we know that challenges often arise around implementing the data model and sample data in a technical production environment in order to assess it's success (Ibid.). To date, the complexity of building systems to support the use and analysis of BIBFRAME data has been a barrier to effective evaluation of the ideal "shape" of BIBFRAME to support LRM user tasks. However, with the data stores and discovery systems being developed by Share-VDE and LD4P, we are

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now in a position to use BIBFRAME's flexibility to our advantage to iterate and test standard BIBFRAME core application profiles to verify their utility for cataloguers and users alike. Once a BIBFRAME core and model are defined and tested, cataloguers and tool developers can create with confidence knowing their work will have wide application.

3. Define MARC use cases in a BIBFRAME environment
   An interesting nuance of the discussion around BIBFRAME standardization is the need to determine use cases and standards to cover what we expect from MARC that has been converted from BIBFRAME. One approach (as represented by the LC converter) is to continue supporting MARC interchange for use in discovery. Another alternative approach could be to utilize BIBFRAME descriptions for discovery purposes, but utilize a much simpler, slim MARC output for inventory control in existing MARC systems. The later approach could simplify conversion processes for libraries moving to BIBFRAME, but would have obvious implications for metadata reuse. Further investigation into these points is timely as LD4P3 is currently developing separate BIBFRAME to MARC processes to support the conversion of native Sinopia BIBFRAME data.

4. Define implementation scenarios for the use of RDA 3R in BIBFRAME
   Along with defining BIBFRAME standards, there is also the need to determine how the larger cataloguing community will be implementing RDA 3R in BIBFRAME to insure data interoperability and reuse. Similarly, where RDA/RDF is utilized independent from BIBFRAME clear mappings should be a priority to ensure interoperability and support use cases for data reuse.

5. Develop and coordinate implementation timelines for both RDA and BIBFRAME
   Implementation timelines are necessary to make clear when both standards will be supported for application and exchange. When timelines are in place, libraries will be able to make more informed decisions about local practice and investments in transition.

Finally, wider community initiatives, best practices, and feedback loops need to continue to develop in order to successfully begin BIBFRAME implementations with a focus on bibliographic control. We have seen the start of a library community of practice around linked data with the establishment of the LD4 Community. The recent recommendations from the PCC Task Group on Sinopia Application Profiles (2020) that the PCC establish workflows for metadata reuse and investigate interoperability with the Share-VDE data model are also promising steps forward for bibliographic control within BIBFRAME. While welcome developments, it is also necessary to create open feedback loops between LC, other large scale projects and BIBFRAME implementers, and to establish relationships with the wider linked data community (Folsom 2020) to develop a BIBFRAME model and supporting systems that will enable bibliographic control. Here prioritizing transparency around ongoing and future developments to the BIBFRAME ontology and technical infrastructure (along with supporting analyses and user testing data) will be necessary to ensure BIBFRAME implementers can move forward on a shared path.

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All of these steps to maintaining bibliographic control in a BIBFRAME environment point to the need for community wide planning, standardization, and transparent communication. As always, innovation will still be necessary to ensure projects move forward in a way that serves libraries and library users, while leveraging the new systems and discovery potential linked data affords. Supporting the basic needs of interoperability through the refinement of a standardized BIBFRAME core will provide the library community with a solid foundation on which to build and facilitate the process of harnessing innovation for wider application.

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