



NATIONAL ENDOWMENT FOR THE

Humanities

DIVISION OF PRESERVATION AND ACCESS

## **Narrative Section of a Successful Application**

The attached document contains the grant narrative of a previously funded grant application. It is not intended to serve as a model, but to give you a sense of how a successful application may be crafted. Every successful application is different, and each applicant is urged to prepare a proposal that reflects its unique project and aspirations. Prospective applicants should consult the NEH Division of Preservation and Access application guidelines at <http://www.neh.gov/divisions/preservation> for instructions. Applicants are also strongly encouraged to consult with the NEH Division of Preservation and Access staff well before a grant deadline.

Note: The attachment only contains the grant narrative, not the entire funded application. In addition, certain portions may have been redacted to protect the privacy interests of an individual and/or to protect confidential commercial and financial information and/or to protect copyrighted materials.

Project Title: Art Tracks: Standardizing Digital Provenance Documentation for Cultural Objects

Institution: Carnegie Institute

Project Director: Neil Kulas

Grant Program: Research and Development

## Part 3: Narrative

**Project Title:** *Art Tracks: Standardizing Digital Provenance Documentation for Cultural Objects*

**Institution:** Carnegie Museum of Art

**Project Director:** Neil Kulas

**Grant Program:** Research and Development, Division of Preservation and Access, Tier II

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### A. Significance

Museums are institutions created to care for and provide access to cultural information for the benefit of the community. This core mission is undergoing a paradigm shift from traditional, *static* publishing models, such as books, catalogues, etc., to *dynamic* models that are produced and consumed across vast, ever-changing interconnected networks. This move, from static to dynamic, fundamentally changes the way in which cultural institutions must maintain and communicate their data, including provenance of cultural objects. *Art Tracks* navigates between the traditional, book-based paradigm of the past and the constantly shifting networked world in which museums must function now and into the future.

Provenance, or the history of ownership, custody, and movement of art, has always been critical for understanding the events, people, and locations that are significant to the history of an object. An important Getty Research Institute publication, *Provenance, an Alternate History of Art*<sup>1</sup> clearly illustrates the compelling stories that might be told, if provenance information was readily accessible and easily parsed. These stories are not contained within the walls of a museum; they cross-geographical and institutional boundaries, connecting the entire history of art into a network of collectors, galleries, museums, auctions, and artists.

Strong digital standards would allow for these stories to be told across collections, through an open, digital exchange of provenance data among museums. Without a structured, standardized way to share this information, researchers and scholars have been limited to manual analysis. However, through shared digital standards and effective tools leveraging those standards, the beautiful complexity of this history can be explored in dynamic new ways, opening up exciting opportunities for both humanities research and public education.

*Art Tracks* creates an innovative, text-based standard for digitizing and serializing provenance, bridging the gap between the traditional, “human readable” form of provenance records, and the future paradigm of Linked Open Data. The [CMOA Provenance Standard](#) is fully compatible with the traditional text-based representation<sup>2</sup>, while also interoperable with emerging digital standards throughout the museum field and the wider community of archives, libraries, and other cultural institutions, offering the ability to communicate this information easily and create dialogues that inform the history of cultural objects.

In early 2013, CMOA launched an Institute of Museum and Library Services (IMLS)-funded project known as *Art Tracks*. Phase One of *Art Tracks* development was completed on schedule in June 2015, successfully established an internal standard for provenance called the *CMOA Provenance Standard*.

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<sup>1</sup> See Part 5: Appendices – Bibliography, for source publication

<sup>2</sup> See Part 5: Appendices – Results from Previous Work/NEH5-CMOA-Provenance-Standar-Examples.pdf

This standard extends the [American Alliance of Museums](#) recommended provenance standard to support structured data. The innovative, text-based model that CMOA developed allows for easy integration with existing collection management systems, while still supporting the structured data needed for advanced research and visualization. This new CMOA standard for recording provenance is now sufficient to allow the sort of sophisticated visualizations imagined for the project. CMOA presented this work<sup>3</sup> at *Museums and the Web* in 2015, and the community response strongly indicated that continuing to pursue this standard across institutions would be a great service to the museum field.

During Phase One, CMOA became increasingly aware that while most museums document provenance, many of them have not yet fully digitized their records. Additionally, even those that have, work with collection management systems (CMS) such as The Museum System (TMS), Collective Access, or KE EMU that do not offer the capability achieved by the *Art Tracks* project. These systems do not fully record structured provenance information, in which each individual datum of information is stored and formatted in a way that allows computers to understand the semantic meaning contained within. While several institutions, including the [FREER|SACKLER](#) and the National Gallery (Washington, DC), have developed institutional techniques to attempt to structure this information through advanced use of their CMS, those formats are not universal and cannot easily be shared with other institutions.

Phase Two of *Art Tracks* will take the *CMOA Provenance Standard* and existing prototypes developed in Phase One and expand them to meet the needs of all collecting institutions. In partnership with the FREER|SACKLER and [Yale Center for British Art](#), CMOA's *Art Tracks* team will focus on further refinement of the provenance standard to meet the requirements of a range of collecting institutions. The expert staff of our partner institutions with their deep experience and existing projects around provenance and Linked Open Data will be invaluable assets to this standardization effort.

The *Art Tracks* project intends to complete the CMOA extension of the [American Alliance of Museums](#) recommended provenance standard to include the [Extended Date Time Format \(EDTF\)](#) for dates, the [International Standard for Bibliographic Description \(ISBD\)](#) format for bibliographic references, and the [CIDOC-CRM](#) conceptual reference model for Linked Open Data. It will also be extended to support links to location and party authority files as well. The completed *CMOA Provenance Standard* will continue to be both human and machine readable, will fully support Linked Open Data, and will be able to be shared across institutions in multiple formats, including JSON, [RDF](#), and plain text. The human readable version will allow humanities research and publications to continue to be supported in the traditional book-based paradigm, and the Linked Open Data version will also allow provenance records to fully participate in an increasingly data-driven world, and within platforms yet to be imagined.

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<sup>3</sup> Tracey Berg-Fulton, David Newbury and Travis Snyder. "Art Tracks: visualizing the stories and the lifespan of an artwork." MW2015, Published January 15, 2015. See also, Part 5: Appendices – Results from Past Work: NEH5\_PreviousWork\_Paper-for-Museums-and-the-Web-2015.pdf

## B. Background of Applicant

One of the four Carnegie Museums of Pittsburgh, CMOA was founded in 1895 by Andrew Carnegie and is nationally and internationally recognized for its distinguished collection of American and European works from the 16th century to the present. Today, the museum has an established reputation for organizing and presenting groundbreaking exhibitions in a range of media from many different periods.

Major exhibitions have attracted the attention of international critics and situate the museum as a scholarly institution that is also at the cutting edge of contemporary art. The *Carnegie International*, ongoing since 1896 and now occurring every five years, is the museum's outstanding showcase of global contemporary art that enhances Pittsburgh's reputation around the world. The museum's Heinz Architectural Center is the region's preeminent venue for the collection, study, and exhibition of architectural drawings and models, as well as a space for the consideration of architecture as a social discipline. The Hillman Photography Initiative explores and articulates issues around the rapidly changing field of photography in the twenty-first century.

The museum's permanent collection comprises approximately 30,000 objects with particular strengths in painting and sculpture from 1850 to 1910; decorative arts and design from 1850 to the present; contemporary art from 1985 to the present; and works on paper, including Old Master and Japanese prints. The scope extends to, Asian and African art, film and video, as well as nearly 75,000 negatives from the archive of African-American photojournalist and Pittsburgh native, Charles "Teenie" Harris (1908-1998). CMOA is the only U.S. art museum to maintain a photographic archive on this scale with item level cataloging, fully digitized images, and a first-person narrative research methodology, possible because of NEH funding.

In addition to 20 galleries dedicated to the permanent collection, CMOA offers 14 to 16 temporary exhibitions annually. In 2014, the museum engaged more than 375,000 individuals through onsite exhibitions, educational programs, lectures, and events. Web-based and digital projects continue to grow as a priority under the museum's long-range strategic plan, and engage more than a million viewers exploring the museum's online content.

Overseeing CMOA is a volunteer Board composed of 50 members, including four ex-officio and five honorary board members. Twenty-five members of the Board serve on Carnegie Museums of Pittsburgh's Board of Trustees, the museum's governing authority. The Henry J. Heinz II Director is responsible for the leadership, artistic direction, and programmatic activities of CMOA, reporting to the president and CEO of Carnegie Museums of Pittsburgh. The CMOA deputy director oversees daily operations, with primary responsibility for budgeting and administration. Other senior staff members include the chief curator, curator of education, and the directors of development, marketing, and publications.

CMOA is well situated for the development of innovative digital projects with potential impact on museum practice, humanities research, and scholarship. The museum is located in the Oakland neighborhood of Pittsburgh, with Carnegie Mellon University bordering on the east and the University of Pittsburgh immediately to the north. CMOA has collaborated with arts and humanities faculty from both universities on several digital projects including the Teenie Harris Archive and *Art Tracks*, Phase One. In addition, Carnegie Museums of Pittsburgh maintains a well-resourced central IT department, which provides technical support for the museum's digital initiatives. CMOA has maintained its collection data

on the KE EMu database system since 2000, and over the last five years the museum has invested heavily in upgrades to digital images, data cleanup, and improved collection documentation with an eye to future dissemination on the Web.

CMOA's strategic plan prioritizes digital projects as a means of achieving leadership in the arts. CMOA Henry J. Heinz II Director, Lynn Zelevansky, noted in the addendum to her introduction of the plan that, "In 2015, certain experimental programs are pushing the museum into a leadership position as fast, or faster, than our exhibitions. The Hillman Photography Initiative; our innovative *Art Tracks* project, which focuses on provenance, or the lives and travels of artworks; and our time-based media project funded by the A. W. Mellon Foundation are examples of this." Completion of *Art Tracks* Phase One in 2015 and development of Phase Two (the subject of this proposal) are specific strategic objectives for 2015-2017.

### **ART TRACKS PROJECT HISTORY**

In early 2013, CMOA launched an IMLS-funded project known as *Art Tracks*. This project was originally formulated as a data visualization project, focusing on the movements of artwork in time and space. As development of the project began, it became clear that the institutional standards used for recording provenance were insufficiently precise to allow for the sort of visualizations desired for the project. At that time, CMOA began a review of literature and engaged in inquiry with other museums to discover how provenance was recorded, and what existing industry standards were available, if any. This initial review indicated that, although there was great interest in the subject, the museum community has not yet formalized a strategy for provenance digitization and structure.

CMOA then began developing an internal standard for recording and digitizing the provenance records of the museums' collection, now known as the *CMOA Provenance Standard*. This text-based standard can be automatically converted into structured data compatible with the CIDOC conceptual reference model, an industry standard model for expressing cultural heritage information. Importantly, it has the capability to maintain a human-readable form that allows the information to be stored easily within the museum's existing collections management system. This standard was implemented as both computer software and a written document, and was tested against both the museum's extensive provenance records and provenance records of several other institutions, including The Walters Art Museum, the National Gallery (Washington, DC), and the Yale Center for British Art.

*Art Tracks*, as it exists today, comprises three key components that integrate to form a fully functional, proven system for the standardizing, digitizing, and sharing of provenance research data. These components include:

1. The *CMOA Provenance Standard*, an extension of the suggested standard from the American Alliance of Museums that adds rigor and precision to this human-readable standard, while allowing for computer parsing of the text.
2. The [Museum Provenance Library](#), the software reference implementation of *the CMOA Provenance Standard*. This software is capable of converting a textual provenance record, written using the *CMOA Provenance Standard*, into structured data. It is also capable of converting appropriately structured data back into text, allowing the software to convert automatically between text and structured data without losing information. The library is also designed to be permissive, allowing minor variations of the standard to be corrected without human intervention, while also flagging these changes for human review.

3. *Elysa*<sup>4</sup>, a web-based user interface for museum professionals that assists non-technical museum staff in quickly and easily reviewing and modifying provenance records written using the *CMOA Provenance Standard*. This tool is connected to CMOA's collection management system, and displays the provenance record in three different forms: as a traditional provenance record, as an editable list of fields, and as timeline visualization. Modifying any data field automatically updates the other two forms, allowing for quick feedback and multiple methods to detect errors. The software also uses the automatic flagging enabled by the *Museum Provenance Library* to indicate records that need human review. The system is designed to maintain the existing collections management system as the authority for the provenance data, while greatly simplifying the writing and understanding of provenance records.

Since the stated goal of the *Art Tracks* project is to impact general museum practice, both the standard and all related software have been designed with the flexibility needed to support future adoption by other museums. In order to promote use of this standard and facilitate sharing and further development of the technology throughout the museum field, all *Art Tracks* software, documentation, and standards have been released to the community as open source under the MIT license, which permits full reuse of the code in both commercial and noncommercial applications with no cost to the user.

Phase One of *Art Tracks* is now development-complete, and is currently being implemented within CMOA for provenance data standardization, an in-gallery interactive, and as a platform for several collaborations with external parties, including leading museums in the field of provenance research. Further details of this work can be found in our paper; [Art Tracks, Visualizing the stories and lifespan of an artwork](#), presented at *Museums and The Web* in March of 2015. All related software has been open-sourced and shared with museum professionals who are interested in provenance digitization. Additional documentation for the project can also be found at: <http://www.museumprovenance.org>.

One of the major goals of that project was to create a tool that would be willingly used by people and organizations outside of the development effort. The target audience for this software is museum professionals: registrars, curators, provenance researchers, and collections database managers. As a measure of ongoing evaluation, CMOA engaged a full-time registrar throughout the development process who worked closely with the *Art Tracks* project team to test the software and standard, providing constant feedback on the usability of the tool. The addition of this staff person allowed for a methodical and intensive development of *Art Tracks* as an effective tool for museum professionals working with provenance data. Additionally, Design for Context, a Washington, DC-based consulting firm, performed a usability study of the tool, and provided extremely helpful suggestions, and a revised design that significantly improved the usability of the *Elysa* tool in preparation for *Art Tracks'* release.<sup>5</sup>

The *Art Tracks* project also greatly benefited from consultation with the Yale Center for British Art and the National Gallery of Art. These museum colleagues provided CMOA with sample data and insight into their methods, which helped to inform the development of the *CMOA Provenance Standard*. Without their help, the *Museum Provenance Library* would not be nearly as robust or functional. In preparation

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<sup>4</sup> CMOA chose the name *Elysa* for the user interface software because the full names of women are often excluded from provenance records and public documentation of collections (e.g., Mrs. Smith or Mrs. John Smith). The name also refers to a trusted staff member and beneficiary of Andrew Carnegie, Mrs. Nichol, who the *Art Tracks* team discovered was named Elysa through records presented in the 1915 census of the Carnegie household.

<sup>5</sup> See Part 5: Appendices – Results from Previous Work: NEH5-ResultsFromPreviousWork.pdf “Elysa Tool”

for the broad dissemination of *Art Tracks*, CMOA has also taken advantage of the many provenance records published online by other museums as a method to test our tools against additional records.

The initial phase of *Art Tracks* was an extremely successful pilot project, both in accomplishing the goals set forth by the IMLS-funded grant and in identifying and building an infrastructure for advanced implementation. CMOA's dissemination and publication of the work has also created a ready network of museums and museum professionals eager to employ the standard. CMOA has proven that it possesses the capacity and the expertise to convert provenance into a digital format, as well as build tools that verify that the *CMOA Provenance Standard* can work within a collecting institution of our size and scope.

Using the technology behind Phase One of *Art Tracks*, CMOA now has the ability to explore questions that would have been difficult or prohibitively time-consuming before; for instance, "What works in our collection were in England during WWII?" or "How many of our works were, at some point, owned by the same collector?" While these questions could have been answered before through traditional, laborious research, *Art Tracks* allow us to respond to these questions in minutes or hours, rather than days or months.

CMOA has already begun to use *Art Tracks* to analyze the history of the museum's collections through new academic research, and to create a visitor-facing experience that connects particular artworks to the story of the collection. The in-gallery interactive component of the *Art Tracks* project is scheduled to debut at CMOA in June 2015. We have published our initial work as a peer-reviewed paper in the 2015 *Museums and the Web* journal. Additionally, the American Art Collaborative, an A. W. Mellon Foundation-funded initiative for Linked Open Data in the museum world, has been presented *Art Tracks* as a model for uses of linked data<sup>6</sup>.

### **C. History, Scope, and Duration**

Phase Two of the *Art Tracks* project will begin in January 2016 and will take place over a two-year period, concluding in December 2017. The first year will focus on working with partners in the museum field to further refine the standard and the infrastructure required for this work; the second year will focus on testing and dissemination of *Art Tracks* among collecting institutions through the Northbrook Initiative (See Narrative Section H – Intended Audience and Dissemination), as well as independent promotion of the work at national conferences and through independent channels.

CMOA, the Yale Center for British Art (YCBA), and Freer Gallery of Art and Arthur M. Sackler Gallery of the Smithsonian Institution (FREER|SACKLER) will collaborate on creating and defining a Linked Open Data representation of provenance, suitable for capturing the history of all three organization's collections. Simultaneously, the *Art Tracks* project team will be seeking input from leading organizations in the field of collections management and library sciences to further refine the bibliographic structure of the *CMOA Provenance Standard*.

CMOA's plan for dissemination of *Art Tracks* involves a collaborative, multi-museum, evaluation of the *CMOA Provenance Standard* and the *Elysa* tool through hands-on use in what will be called the Northbrook Initiative. The Northbrook Collection was a large and important Old Master collection that

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<sup>6</sup> See AAC youtube publication (1/15/15) <https://youtu.be/8kXK7yY6MUC?t=34m>

was dispersed broadly to museums and collectors around the world in the early 20<sup>th</sup> century. Because the collection's provenance is unusually well documented, it provides an ideal case study for initial dissemination of the *CMOA Provenance Standard*, with the added benefit of creating a rich subset of work that can be used to create visualizations with shared provenance data from participating institutions. As proof-of-concept, CMOA will develop and share an interactive version of the Northbrook Collection data as a gallery interactive. And while this is not the primary goal of the project, it is an essential component of both proving the effectiveness of the standard and for disseminating the results of the *Art Tracks* project.

#### **JANUARY–JUNE 2016:**

- Complete the written definition of the standard, particularly through inclusion of EDTF, ISBD, and CIDOC-CRM. This will be done in conjunction with software development on the *Museum Provenance Library*, verifying that the structure and intent of the document is realizable with code. Work closely with YCBA and FREER|SACKLER to achieve the objective of creating a highly functional Linked Open Data representation that works within all organizations' provenance models.
- Continue work by CMOA staff provenance researchers to complete initial research on the extent and scope of the Northbrook Collection. Identify at least five beta partners whom we will engage in testing the data submission and collection functionality of the Northbrook Initiative.
- Identify partners and begin preparation for a "Digital Scholars Day", which will be held at CMOA in fall 2017.
- Use the provenance data of our partner institutions to evaluate the capabilities of the standard.
- Train internal staff and perform user testing of the *Elysa* tool to evaluate functionality and usability.

#### **JULY–DECEMBER 2016**

- Focus on user interfaces and documentation while continuing to refine the standard through extending the *Elysa* tool to support functionality enabled by additions to the code. Work to extend import/output of *Elysa* to support both our partner institutions and the inclusion of future Northbrook work.
- Begin preparations for our narrative and humanities research for the Northbrook Initiative, to ensure that the correct data are provided to the partner list. Finalize our list of initial partners for the Northbrook Initiative.
- Conduct partner visits to complete Linked Open Data standardization efforts.
- Prepare two papers: one for submission to the 2017 CIDOC-CRM conference, describing our research on representing provenance in Linked Open Data; another for submission to a digital humanities conference<sup>7</sup>, on the use of EDTF in cultural heritage representations.
- Host a "Digital Scholars Day". The convening will include a full presentation of the work completed through the *Art Tracks* project and will engage a range of experts within the digital humanities realm. The goal is to solicit input and feedback through a training and collaborative work session to evaluate the software and standard.

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<sup>7</sup>Annual Conference of the Alliance of Digital Humanities Organizations, date, and location TBD; DLF Forum, date and location TBD



## JANUARY–JUNE 2017

- Focus on development of the Northbrook Initiative, with an emphasis on obtaining, collecting, and storing submissions of provenance data from our partners. Test integration points and reveal where we need to modify the standard to support external data. Complete the initial user interface design for the Northbrook interactive experience (see Dissemination and Intended Audience section below), and begin its development. Complete migration of provenance data from all identified partners.
- Prepare two papers: one for submission to a humanities conference<sup>8</sup> on learnings from the Northbrook Initiative, another for Museum Computer Network 2017, on multi-museum digital interactives.
- Project Director to participate in NEH meeting in Washington, DC, to showcase Art Track's ongoing work, as well as to address major topics in cultural heritage research and development.
- Finalize the standard and publish it on the *Art Tracks* website for review by partners and other community members.
- Prepare a paper for *Museums and the Web* 2017 on our use of ISBD in the standard to track the sourcing of provenance data.
- Identify and invite scholars for the "Humanities Scholars Day", to be held in late 2017 (see below)

## JULY–DECEMBER 2017

- Complete development of the gallery interactive visualization tool and provide copies and assistance to any of the partner institutions that would like to use it. Install in-gallery versions of this interactive within CMOA's galleries (see Gallery Interactive section on page 13)
- Host a "Humanities Scholars Day", focusing on the completed Northbrook Initiative and exploring other uses of this data and technique for future scholarship in the humanities.
- Conduct evaluation of the effectiveness of the Northbrook Initiative through a survey of partner institutions; publish results on the project website.
- Verify that all code, documentation, and other related documents have been published, either on the project website or the museum's [GitHub](#) account.

## D. Methodology and Standards

CMOA's objective for development of *Art Tracks* has always had a foundation in open source programming, with the goal of providing a free and functional resource to the entire museum field. Throughout the development process, CMOA will use GitHub, an industry standard repository for open source code for collaboration with our partners, as well as using it as platform for sharing the resource with the museum community. The source code of all software developed will be hosted on [CMOA's GitHub account](#). CMOA will practice open development, where our in-progress code is shared with the community for input and collaboration at all stages of development. We will use GitHub's "Issue Tracker" to document development milestones for maximum transparency. We will also use industry best practices to both document and test our code. All outside software used in this project will be either open source or have free versions available for museum professionals. Any code developed by

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<sup>8</sup> College Art Association annual meeting, New York City, February 2017; American Alliance of Museums annual conference, St. Louis, May 2017

CMOA will be open and available to all institutions under the [MIT license](#), the most appropriate of the open source licenses for future use of this standard in order to encourage widespread adoption.

CMOA will also work to support museum standards, the ability to import from and export to CIDOC-CRM. Additional goals for this project include support for importing data from [LIDO](#), existing museum authority files and comma separated value (CSV) from museum collections management systems. CMOA will also use industry best practices in support of JSON application program interfaces (API), with a special focus on exploring the utility of [JSON-LD](#) within the context of museum data.

The *CMOA Provenance Standard* will be published as a PDF and HTML on the project website as well as via a GitHub repository containing the text of the standard to track changes and revisions. The Linked Open Data mapping developed in partnership with YCBA and FREER|SACKLER will also be published on the project website.

CMOA will submit scholarly papers on the integration with existing standards from other domains, such as EDTF and ISBD, to journals outside the museum community to solicit feedback.

To test our tools, CMOA will be using objects and provenance records from the CMOA collection, the YCBA collection, the FREER|SACKLER collection, and from all Northbrook Initiative partner institutions. CMOA will also continue to test our tool against data from a wide variety of openly published museum provenance records that use the AAM standard.

## **E. Work Plan**

The three main components of the project, the *CMOA Provenance Standard*, the *Museum Provenance Library*, and the *Elysa* tool, are closely related and will be developed in parallel throughout the project. Each of these tools will need to be extended to support changes to the standard. Rather than address each component independently, we will implement our plan to extend the standard and make any explicit software changes required to support these extensions.

### **DATE LOGIC AND INTEGRATION**

Cultural heritage dates are complicated, as are computer dates. The current version of *Art Tracks* implements a proprietary model for handling this complication using Julian Days, a standard from the astronomy community that appropriately supports dates earlier than 1500 CE. The standard also handles digital representations of precision and certainty through custom fields within the data structure. During CMOA's initial presentations on *Art Tracks* to the museum and digital humanities community, it has become clear that a consensus opinion is forming around the use of [EDTF](#) for representing this information. EDTF, a [Library of Congress](#)-proposed extension of the [ISO 8601](#) date-time standard, is a standard developed to handle the fuzziness of cultural heritage dates. Our use of this standard will allow standardized mapping of cultural heritage dates, while maintaining the inherent uncertainty and imprecision associated with them.

Modifying the *Art Tracks* data model to use EDTF is important, but equally important is enabling libraries and software support to use EDTF as an interchange format outside of our standard. To do so, CMOA will develop software to map EDTF concepts both to human-readable strings and to a traditional

computer date-time model<sup>9</sup>. CMOA will also verify and document that EDTF interoperates effectively with CIDOC-CRM. Initial research by both CMOA and the Digital Public Library of America indicates that there is a strong conceptual match between these standards—CMOA will explore and document this interoperability and intends to submit a paper on this research at an appropriate digital humanities conference.

CMOA will extract the date handling code from the *Museum Provenance Library* and convert it into a stand-alone component, suitable for reuse across other projects. This extracted piece of software will then be incorporated back into the *Museum Provenance Library* as the interchange and storage format for provenance data.

The date handling code will be designed to convert a subset of EDTF into English text and into standard date representations within the host language. CMOA's goal is to develop software in both Ruby and JavaScript. The Ruby library is important because it is both the language in which the *Museum Provenance Library* is written and currently, the most robust reference implementation of EDTF. However, for this to be useful for online implementations, it is also important to have an implementation of the software in JavaScript that will allow for browser-based user experiences. Developing this code in two languages will ensure that none of the implementation details that we are exploring is language-specific. Once sufficient support exists in both JavaScript and Ruby, CMOA will extend both the *Elysa* tool and the *Museum Provenance Library* to handle EDTF.

CMOA will develop a stand-alone, web-based utility to explain and document how these various technologies interact with each other. This utility will exist for documentation purposes, as a reference implementation, and as a graphical user interface (GUI) tool within the *Elysa* tool to allow for date picking. We will open-source this widget, and provide suitable documentation to allow others to implement it in their HTML/JavaScript-based applications.

### **LINKED OPEN DATA LOCATION AND PARTY INTEGRATION**

As part of our existing version of the *CMOA Provenance Standard*, we have codified a text-based representation of location that is suitable for human understanding. As part of the Phase Two improvements to the standard, CMOA will specify a useful digital representation of these locations. Several existing internal prototypes based on the draft standard use the [Geonames](#) ontology as an authority source for geographical information. Geonames is the most comprehensive Linked Open Data ontology for locations in use by organizations as diverse as [the Guardian](#), the [US Geological Survey](#), and [Etsy](#). CMOA will support integration with a second ontology, the [Getty Thesaurus of Geographical Names](#), which is well adapted for the arts. A third option that will be an integration with user-supplied authority files such as those generated by a collections management system.

CMOA intends to offer similar support for authority files for party records, drawing on the [VIAF](#) ontology, with additional support for the [Getty Union List of Artist Names](#) and an institution-provided authority file.

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<sup>9</sup> See Part 5: Appendices – Results from Previous Work: NEH5-ResultsFromPreviousWork.pdf “Mapping CIDOC-CRM Date Representations to English”

CMOA does not intend to provide a comprehensive disambiguation strategy for locations or parties as part of this project. Our intention is to allow explicit links to Linked Open Data sources to be included and linked within provenance records, and to allow the software tools that we create to facilitate this linking and basic retrieval of additional metadata from these Linked Open Data sources. Disambiguation is an existing problem for many institutions and over the next three years we expect significant progress to be made in this area; we intend to evaluate and integrate solutions for this as they become available. CMOA will also explore automating submissions to authority files for information within existing records that are not currently available within the authority.

## **SUPPORT FOR BIBLIOGRAPHICAL REFERENCES**

Another area currently lacking within the existing AAM suggested standard for provenance is formal support for provenance bibliography. While the recommendation states, “The sources of information about each owner or transaction should be documented,<sup>10</sup>” it does not specify a format or structure for this and, in practice, sourcing information either appears in footnotes or not at all. In order to allow this information to have the richness and interoperability that Linked Open Data and the web itself allow, the *CMOA Provenance Standard* will need to develop robust support for integrating this information.

CMOA will develop support for this documentation into two existing standards: the [ISBD](#) standard, which is an International Federation of Library Association standard for bibliographic data; and the [FRBR conceptual reference model](#). The ISBD standard is particularly relevant because it, like the *CMOA Provenance Standard*, is both computer and human readable. This means that it can be directly integrated into the *CMOA Provenance Standard* without modification. Compatibility with FRBR is relevant due to the direct support for interoperability with [CIDOC-CRM](#), the Linked Open Data conceptual reference model for museums and other cultural heritage institutions. These two standards, one from the library world and one from the museum world, have recognized the utility of interchange, and have developed [FRBRoo](#), a “... solution of the problem of semantic interoperability between the documentation structures used for library and museum information.<sup>11</sup>”

FRBRoo means that CMOA’s citation support uses community-generated standards for mapping between museums and bibliographical data, and merely needs to implement these community standards to have full interoperability in both worlds.

## **LINKED OPEN DATA WITHIN THE HUMAN-READABLE SERIALIZATION**

One of the major goals of this project is to support Linked Open Data, not only by serializing our provenance representation against the CIDOC-CRM, but also by allowing links to external authority files for the parties, locations, and bibliographical references represented within the data. One of the other major goals of these extensions to the *CMOA Provenance Standard* is to maintain the human-readable nature of the text serialization of the data, allowing a sufficiently competent person to write provenance records without software assistance and to allow someone with experience in reading provenance records to understand the record without any knowledge of the *Elysa* tool.

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<sup>10</sup> See Nancy H. Yeide, Konstantin Akinsha, and Amy L. Walsh. *The AAM Guide to Provenance Research*. American Association of Museum, Washington DC, 2001, pp. 33-34.

<sup>11</sup> [http://www.cidoc-crm.org/frbr\\_inro.html](http://www.cidoc-crm.org/frbr_inro.html)

There is not an obvious way to support both of these goals simultaneously. Representing links to external authorities in RDF is trivial, but maintaining the human-readable component of the *Elysa* tool while supporting Linked Open Data is a significant challenge. This is one of the major research needs for this project. The success of our project depends on extending the *CMOA Provenance Standard* to solve this problem. We will work closely with both of our partner institutions to verify that our recommendations are both clear and useful.

### **IMPORT/EXPORT INTERCHANGE**

Once the Linked Open Data representation of this standard is complete, it will not only need to be serialized into human-readable text, but it should also be serialized into standard digital forms for use in non-Linked Open Data applications. CMOA will implement JSON digital representations of this form.

This representation will be a [JSON-LD](#) serialization of the CIDOC-CRM Linked Open Data representation of this information. JSON-LD is a JSON serialization of Linked Open Data that can be interpreted both by applications expecting RDF and applications expecting JSON. This will allow applications that require the rich semantic meaning conveyed through the CIDOC-CRM to have full access, while allowing simpler applications that merely need access to structured information to use industry standard parsing tools to access the same information as standard JSON.

CMOA will develop improved support for multiple data import formats. Currently, the *Elysa* tool requires very little in the way of data provided by partner institutions, but it is important to be a consumer of Linked Open Data, not merely a producer. For example, CMOA will add support within *Elysa* for an institution to provide a Linked Open Data reference to a work of art and generate the provenance record from that data; it should also be possible to do the same with an existing [LIDO](#) XML file. Further, it should be possible to accept a standardized CSV file from institutions that are not currently implementing either of these standards.

### **PARTNERSHIPS WITH OTHER INSTITUTIONS**

CMOA has secured letters of commitment from the Yale Center for British Art and Freer Gallery of Art and Arthur M. Sackler Gallery of the Smithsonian Institution. Both FREER|SACKLER and the Yale Center for British Art are pursuing a Linked Open Data model for provenance, formalizing the mappings between the information contained within their collections management system to the CIDOC-CRM. The Yale Center for British Art is one of the most progressive and experienced institutions in North America when it comes to both Linked Open Data and the CIDOC-CRM<sup>12</sup>. The FREER|SACKLER has also been engaged in a significant digitization project focusing on provenance, utilizing relationships within its collections management system, and is interested in translating this information into a universal standard.<sup>13</sup>

Rather than generate three different mappings, all three institutions feel that collaborating on this project will help ensure interoperability and greater acceptance of the standard. The CIDOC-CRM has an enormous flexibility when it comes to mapping cultural heritage information to Linked Open Data ontologies, but there are discrepancies between the traditional understanding of provenance and the more nuanced approach of the conceptual reference model. In particular, provenance often conflates

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<sup>12</sup> See Part 5: Appendices – Letters of Support

<sup>13</sup> See Part 5: Appendices – Letters of Support

ownership, custody, and location of a work, but these three time/space vectors are independent within the CIDOC-CRM. Ensuring that this mapping is well formed is essential.

All three institutions have different areas of focus and all three have data in different formats. A consensus mapping that supports the needs of all three and allows full interoperability among their records would be an impressive example of inter-museum collaboration and a strong model for the museum community at large.

### **GALLERY INTERACTIVE**

As part of our dissemination strategy, CMOA will engage no less than five museums to test and adapt the *CMOA Provenance Standard* to ensure interoperability with other museum collections (see Intended Audience and Dissemination section below and Appendix attached). This plan will require the adaptation of a web-based version of the *Elysa* interface, for use by participating institutions. Additionally, gallery interactive will be developed for participating museums, which will require further development. This work will be based on the interactive experience that debuted in CMOA galleries in June 2015, as part of *Art Tracks* Phase One.

As part of our technical work plan, CMOA will construct an HTML5 interface, suitable for in-gallery touchscreens, iPads, and online experiences. This interactive will display the compiled provenance of the Northbrook Collection, tracing each artwork, from its creation to its entry into to the Collection, eventual sale, and subsequent acquisition by the museums, which would be participating in the testing of the software and standard. The interactive will also provide links back, when available, to each partner's records about that particular work. This interactive experience will then be integrated with as many records as possible from the Northbrook Collection. Instructions and documentation will be provided for each contributing institution using the interactive, either in-gallery, as a self-hosted entity on the institution's website, or as a link to the hosted interactive.

### **DOCUMENTATION AND DISTRIBUTION**

Software is only as good as its documentation; throughout Phase One, CMOA has made a concerted effort to document the *Art Tracks* software using industry-standard techniques, through online comments, automatically generated documentation, examples, and tutorials. Phase Two will continue this precedent, with additional documentation and improved automated testing. We will continue to maintain the documentation and examples for all open source libraries developed through the *Art Tracks* project and make them available at <http://museumprovenance.org>.

The actual code will be maintained on the museum's GitHub account. CMOA will also host a demo version of the *Elysa* tool, for use by institutions evaluating the software, as well as for institutions without sufficient technological resources to maintain their own version. CMOA will explore existing tools such as [Heroku](#) and [AWS](#) to allow institutions interested in hosting their own version of this tool to do so easily. We will host the date-test cases generated for EDTF support. All the publications on this website will be distributed under the Creative Commons [Attribution-ShareAlike 4.0 International](#) license to facilitate usage and implementation.

CMOA currently uses GitHub to manage issues and engage with the community on open-source projects—all discussions, feature requests, and bugs will be handled through this system. This will

promote transparency, collaboration, and community oversight of the project throughout the development process.

## F. Staff

**Neil Kulas** is the CMOA Web and Digital Media Manager, and will be providing project management and support for this project. Previously, he was Manager of Web and Interactive Media at Milwaukee Art Museum, where he oversaw the design and development of web and interactive projects. Neil has fifteen years of experience working as a designer and front-end developer for agencies, retail e-commerce, and non-profit organizations. Neil has an MFA from Hunter College, City University of New York and a BFA from Cleveland Institute of Art.

**Lulu Lippincott** is the CMOA Curator of Fine Arts. She holds a PhD in European history from Princeton University, with a dissertation on art collecting in 18th-century England, and a BA of Art History from Yale University. She has supervised provenance research on CMOA's Fine Arts collection since 1990 and first conceived *Art Tracks* as a data visualization project based on museum records. As manager of CMOA's Teenie Harris Archive, she is experienced in developing digital projects of national significance and scope. For *Art Tracks* she serves as a curatorial consultant, advising on provenance standards, museum users, and academic relationships.

**David Newbury** was the Lead Developer of the pilot phase of *Art Tracks*, who has provided a letter of commitment<sup>14</sup> to continue the software development of Phase Two of the project. Previously, he was a lead developer at American Eagle Outfitters, and was one of the principle architects of their internal API. He has also been the lead developer on several large humanities projects, including a First Nations language survey for the University of Victoria, in BC, Canada, and the redevelopment of the Green Guide for the Pennsylvania Center for Environmental Education. He has 20 years of professional development experience and has taught interactive development at the University of Illinois, Chicago and Carnegie Mellon University. In addition, David has won numerous awards for his work in film and has a BA in film production from Pennsylvania State University.

**Tracey Berg-Fulton** is the CMOA's Collections Database Associate and has provided both research and user testing for the *Art Tracks* Project. A member of the *Art Tracks* team since July 2014, she has been essential in providing user testing, feedback, and insight into the workflows and processes that this project is designed to support. She has a MLIT from the University of Glasgow in Art History, a BA from Otterbein University, and is on the board of the Registrar Committee of the American Alliance of Museums. Previously, she was the Chief Registrar at the August Wilson Center for African American Culture in Pittsburgh, PA, and Assistant Registrar at the University of Oklahoma.

This position of Collections Database Associate is currently funded as part of the initial IMLS grant for *Art Tracks* Phase One, through the end of 2016. NEH funding will be applied to continue the role of Collections Database Associate in year two of the proposed project, following the required procedure

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<sup>14</sup> See appendix for letter of commitment from David Newbury. Based on NEH guidelines, CMOA will follow the required procedure for procurement contracts through an open and free competition for the position of lead developer for the *Art Tracks* project. Due diligence and consideration will be given to each proposal and contracts will be awarded based on the bid or offer that is most advantageous, considering price, quality, and other factors.

for procurement of contract workers. This position will be essential in both researching and formatting the provenance metadata for the Northbrook Initiative.

**Travis Snyder** is CMOA's Collection Database Administrator. He has been part of the *Art Tracks* team from the outset and has been an instrumental resource for understanding the existing metadata contained within the museum's collections management system. He will continue to provide expertise and access to the Museum's collections management system and will work with the rest of the *Art Tracks* team to ensure standards integration and interoperability with the rest of the museum's digital information. Travis has been at CMOA since 2009, and has a BFA from Slippery Rock University in Pennsylvania.

**Marilyn Russell** is CMOA's Curator of Education and a member of the museum's department of education since 1995. She will ensure that the gallery interactive has exceptional educational impact that aligns with the museum's interpretive philosophy and strategy developed by her team. Additionally, as a member of the Gallery Engagement Group, Marilyn will assist in the authoring and facilitation of audience surveys and their evaluation to assess strengths and opportunities for improvement in visitors' use and understanding of the interactive within the gallery experience. Marilyn has an MA in Art History from the University of Michigan, Ann Arbor and a BA from Chatham University in Pennsylvania.

## **G. Sustainability and Evaluation**

### **LONG-TERM PRESERVATION OF PROJECT DELIVERABLES**

*Art Tracks* is one of the core initiatives identified by CMOA in its strategic plan. As such, the long-term success and sustainability is not only dependent on those directly involved in the day-to-day research and development of the project, but also on the entire institution. Phase Two of *Art Tracks* is part of a series of ongoing improvements and developments to this software and additional phases are actively being developed and planned for 2018 and beyond. We are also exploring additional uses of this software to support initiatives both at CMOA and throughout the Carnegie Museums of Pittsburgh family.

As part of CMOA's ongoing commitment to sustaining the *CMOA Provenance Standard*, the *Museum Provenance Library*, and the companion *Elysa* tool, the museum is committed to the stewardship of these open source projects. We will continue to maintain the project website as a hub for documentation beyond the scope of this grant.

The *Art Tracks* team will meet regularly with a cross-functional steering group comprising members from across the Carnegie Museums of Pittsburgh and chaired by Vice President of Information Technology, Ed Motznik (See Part 5: Appendices – Data Management Plan). The explicit goals of these meetings are to define CMP policies regarding internal resource development, governance, and disaster recovery. *Art Tracks* will align with these internal policies and incorporate best practices for data management throughout the course of the project. For more information regarding the museum's technological capabilities, please see Part 5: Appendices – Data Management Plan.

Throughout the project, CMOA will identify key museum staff for training in these tools and standards, both for evaluation of *Art Tracks* as well as to ensure its support and adoption internally. CMOA will also identify additional developers within current CMOA and Carnegie Museums of Pittsburgh staff for



training on the tools and design of the software, as a measure of project sustainability. This will ensure that long-term support of the code base extends beyond the core *Art Tracks* team. Within the existing *Art Tracks* team, CMOA will also formally identify a community maintainer of all open source software developed. The maintainer will be responsible for addressing the community, evaluating and fixing software bugs, responding to community issues and feedback, integrating contributions from the community, and supporting the software throughout the grant phase and beyond.

## Evaluation

Evaluation is integrated throughout the work plan of this project—CMOA’s strategy of continuous deployment, and use of the *Art Tracks* tools by staff throughout the institution, means that feedback is generated on a daily basis. The *Art Tracks* developers will regularly meet with and solicit additional feedback from staff on possible improvements to the workflow and tools. As additional partner institutions begin to apply these tools to their collections, we will discover new and interesting ways to break the application, for example by using methods of transfer which were not previously identified. This measure of evaluation will identify additional ways in which the *CMOA Provenance Standard* will need to be extended.

The Digital Scholars Day is another vehicle for evaluation—presenting our work-in-progress to experts throughout the local digital humanities community will allow for essential input and feedback from the community. Further, our open development process will allow interested community members to watch and provide feedback on development throughout the project.

Within the Northbrook Initiative, CMOA will identify at least five partner institutions, which are known to have artworks that were a part of the Northbrook Collection and which also are leaders in the museum community in the area of digital technology. CMOA will use their feedback on the submission and evaluation process to ensure that the project’s technology does not present a barrier to participation. Once the gallery interactive is deployed, CMOA will distribute a survey to all partnering institutions soliciting feedback on the process and project.

As part of CMOA’s onsite gallery interactive, the museum’s Gallery Engagement Group will conduct a series of observational tracking and timing studies along with questionnaires to assess the strengths and opportunities for improvement in the visitors’ use and understanding of the interactive. A heavy emphasis on formative evaluation will gather feedback from everyday visitors, including responses to labels and graphics developed as part of the interactive experience.

Additionally, CMOA will use Google Analytics to capture on-screen interactivity. The number of touch-events, content selections, and duration metrics will, over time, illustrate a more summative and granular view of the interactive experience. The Gallery Engagement Group will regularly review the resulting reports contributing to the overall evaluation of the Northbrook interactive gallery experience. Tracking and timing studies, along with analytics reports and questionnaires, will be re-administered whenever significant changes are made to the interactive or its installation in the galleries. These results will be shared with all participating institutions.

## H. Intended Audience and Dissemination

The primary audience for Phase Two of the *Art Tracks* project is scholarly, collecting institutions whose accreditation requirements<sup>15</sup> are explicit about compliance with AAM guidelines for holdings of artworks pre-1930s. However, *any* museum collecting objects with documented provenance are potential adopters of the *CMOA Provenance Standard*. Additionally, with the Linked Open Data philosophy being incorporated into the project, engaging with the Linked Open Data community, as well as with the library and archives community will significantly improve the outcome of *Art Tracks*. Many improvements to the standard are designed to enhance interoperability within those communities. In order to engage with them, it is important that CMOA have high visibility and accessibility to these intended audiences. This will be achieved by presenting *Art Tracks* at not only museum conferences, but also those specifically focused on the digital humanities and library community. Additionally, the open source software managed on GitHub will provide further exposure and transparency about the project's progress and encourage additional community input.

### NORTHBROOK INITIATIVE

As a subset of the primary audience, *Art Tracks* will specifically target museums that hold artworks previously associated with the Northbrook Collection. CMOA has identified more than 30 institutions that hold works from this collection, encompassing both mid-size and large institutions throughout the United States and across world. See the attached appendix<sup>16</sup> for an index of known Northbrook works and their present locations.

The Northbrook Collection was selected as a vehicle for deploying the *CMOA Provenance Standard* due to its relatively well-documented provenance and the widespread nature of its dispersal among collecting institutions. Beginning in the late 18th century, three generations of the Baring family, all bankers, formed one of the finest collections of English, French, Italian, and Dutch paintings in Britain. In the 1920s, the fourth generation sold works through private sale and public auction, and today many objects from the collection can be found in museums throughout the United States and Europe, including six examples in the collection of CMOA. At the time of submission, objects from the Northbrook Collection have been traced to over 30 institutional and private owners, offering a diverse and appropriately challenging set of participants to engage and test the efficacy of the *CMOA Provenance Standard* and software as a viable resource for use at a variety of institutions, while encouraging use of the *CMOA Provenance Standard* within these collections.

CMOA will present institutions participating in the Northbrook Initiative with access to the software tools, as well as with a hands-on tutorial and methodology for the *Art Tracks* project, for use in recording provenance of individual objects related to the collection. It is not essential for the project that all institutions with work previously held in the Northbrook Collection collaborate with the project. The request from CMOA would be modest in scope, with typically less than five metadata records attributed to the Northbrook Collection per institution.

The primary goal of the Northbrook Initiative would be to verify, through museum collaboration, that the *CMOA Provenance Standard* is capable and usable by many different institutions. By obtaining, parsing, and dealing with issues presented by institutions globally, CMOA will learn about provenance

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<sup>15</sup> [AAM accreditation standards and best practices for collections stewardship.](#)

<sup>16</sup> See Part 5: Appendices – Dissemination Plan

formats that we would otherwise have had no access to, and will receive feedback from many institutions beyond those with which CMOA traditionally partners. By creating a web-based version of the *Elysa* tool, any participating institution will be able to provide provenance information about a work previously in the Northbrook Collection and subsequently become exposed to the *CMOA Provenance Standard* and the tools around it. CMOA would support import of this data via several different formats—these requests for provenance data will help CMOA in determining the range of formats that institutions might use, contributing invaluable feedback and significantly improving the scope and effectiveness of the tools.

The secondary goal of the initiative is to encourage participation of museums by leveraging the proposed gallery interactive experience based on the data visualization component of the *Art Tracks* project. CMOA will present this interactive to museums participating in the Northbrook Initiative as a demonstration of the *CMOA Provenance Standard* and the shared benefits of Linked Open Data. An example of the interactive experience is currently being piloted in CMOA galleries as part of *Art Tracks* Phase One and a screen shot of the visualization can be found in the appendix<sup>17</sup> to this application.

This system—the collection interface and the visualization—will be made available at the completion of this grant for use by any institution that wishes to trace the ownership of a body of works. Future deployments of this software could be used to trace the history of particular artists, galleries, or any other grouping of work that is of interest to an institution.

While the primary scholarly audience for Phase Two of *Art Tracks* will serve as a significant part of the museum’s dissemination plan, we have additional dissemination goals detailed in the appendices that include focused workshops, symposia, internal training, mentorship, and related earned and paid media marketing. Please refer to Appendix Section 5 for more of the CMOA strategy for engaging audiences through the *Art Tracks* project.

## **Glossary of Terms for *Art Tracks***

**AWS** - Amazon Web Services; Amazon’s cloud computing platform.

**application program interfaces (API)** - A set of routines, protocols, and tools for building software applications. The API specifies how software components should interact.

**Attribution-ShareAlike 4.0 International license** - A Creative Commons license allowing both sharing and adaptation of the content without charge, as long as credit is given and the modified results are also shared.

**CIDOC** - The ICOM (The International Council of Museums) International Committee for Documentation.

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<sup>17</sup> See Part 5: Appendices – Results from Previous Work

**CIDOC-CRM** - The CIDOC Conceptual Reference Model is a conceptual model that “..provides definitions and a formal structure for describing the implicit and explicit concepts and relationships used in cultural heritage documentation.”

**collections management system (CMS)** - A database and interface commonly used to store information about a museum’s collection. There are multiple commercial vendors that produce CMS software, many of which are used across the museum field.

**Collective Access** - A free open-source software for managing and publishing museum and archival collections.

**comma separated value (CSV)** - A standard format for representing tabular data, such as a spreadsheet.

**Elasticsearch** - An open-source search server based on Lucence Technology from the Apache Software Foundation.

**Extended Date Time Format (EDTF)** - A Library of Congress proposed standard for digitally recording cultural heritage dates.

**FRBR conceptual reference model** - Functional Requirements for Bibliographic Records: A conceptual entity-relationship model developed by the International Federation of Library Associations and Institutions (IFLA) that relates user tasks of retrieval and access in online library catalogues and bibliographic databases from a user’s perspective.

**FRBRoo** - FRBRoo is a formal ontology intended to capture and represent the underlying semantics of bibliographic information and to facilitate the integration, mediation, and interchange of bibliographic and museum information.

**Geonames** - A Linked Open Data ontology and data store containing millions of geographical place names and metadata.

**Getty Thesaurus of Geographical Names** - A structured vocabulary provided by the Getty focused on location names.

**Getty Union List of Artist Names** - A structured vocabulary provided by the Getty focused on artist names

**Github** - An online code repository, commonly and widely used for hosting open source projects

**graphical user interface (GUI)** - A type of computer interface that allows users to interact with electronic devices through graphical icons and visual indicators , as opposed to text-based interfaces, typed command labels or text navigation.

**Heroku** - An online cloud platform, owned by Salesforce, that simplifies hosting online applications.

**HTML** - HyperText Markup Language: The structured markup language used to describe websites.

**International Standard for Bibliographic Description (ISBD)** - A set of rules produced by the International Federation of Library Associations and Institutions (IFLA) to create a bibliographic description in a standard, human-readable form, especially for use in a bibliography or a library catalog.

**ISO 8601** - An international standard covering the exchange of date and time-related data issued by the International Organization for Standardization (ISO).

**JavaScript** - A programming language often used to create online applications.

**JSON** - A format for representing structured, hierarchal data commonly used by web applications.

**JSON-LD** - A RDF serialization of data using JSON as the underlying data structure.

**KE EMu** - A collections management system, used by Carnegie Museum of Art.

**LIDO** - An XML harvesting schema intended for delivering metadata, for use in a variety of online services, from an organization's online collections database to portals of aggregated resources, as well as exposing, sharing and connecting data on the web.

**Linked Open Data** - A method of openly publishing structured data so that it can be interlinked and become more useful through semantic queries.

**NEPIP** - The Nazi-Era Provenance Internet Portal is a searchable registry of objects in U.S. museum collections that changed hands in Continental Europe during the Nazi era (1933-1945).

**RDF** - A family of World Wide Web Consortium (W3C) specifications originally designed as a metadata data model. It has come to be used as a general method for conceptual description or modeling of information that is implemented in web resources, using a variety of syntax notations and data serialization formats.

**Ruby** - A programming language often used for web applications.

**The Museum System (TMS)** - A collections management system.

**uniform resource identifier (URI)** - A string of characters used to identify a name of a resource. The most common form of URI is the uniform resource locator (URL), frequently referred to informally as a web address.

**Virtual International Authority File (VIAF)** - An international name authority file. It is a joint project of several national libraries, including the Library of Congress, and is operated by the Online Computer Library Center.