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Digitally Archiving Architectural Models and Exhibition Designs: The Case of an Art Museum

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Description
[Excerpt] In 2013, a medium-sized art museum located in the Northeast United States received a grant to plan for an electronic records repository. This museum will be referred to here as USAM for brevity. Working as the electronic records consultant on this project, the first major task was to research and inventory the electronic records being created and already existing at the museum, which necessitated scans of network storage, focus groups with departmental staff, and investigations of media included in the physical archives.

In engaging in this research process, certain document types were expected, such as image files, word processed documents and spreadsheets. Although documents of these types were indeed plentiful, an extensive quantity of digitally produced two-dimensional drawings (2D) and three-dimensional models (3D) were found. Specifically, over 37,000 CAD drawings were unearthed during a network storage inventory project, as well as over 6,000 3D models. These files originate primarily in VectorWorks (and its predecessor MiniCAD), AutoCAD, and Rhinoceros. Given the quantity of digitally produced models and drawings existing at USAM, and the need to plan for an electronic records repository, this project is motivated by the following question:

- *By what methods can two-dimensional CAD drawings (2D) and three-dimensional (3D) models be digitally archived for long term preservation and access?*

To answer this question, a review of the relevant literature is first presented, which explores the methods that have been developed for archiving architectural models and exhibition designs. Second, the study methods are presented, which include more detail on the context as well the archiving tests that were conducted. The paper concludes with results and conclusions regarding how architectural models and exhibitions designs are archived at USAM.

Keywords
digital archives, architecture models, exhibition designs, preservation

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In engaging in this research process, certain document types were expected, such as image files, word processed documents and spreadsheets. Although documents of these types were indeed plentiful, an extensive quantity of digitally produced two-dimensional drawings (2D) and three-dimensional models (3D) were found. Specifically, over 37,000 CAD drawings were unearthed during a network storage inventory project, as well as over 6,000 3D models. These files originate primarily in VectorWorks (and its predecessor MiniCAD), AutoCAD, and Rhinoceros. Given the quantity of digitally produced models and drawings existing at USAM, and the need to plan for an electronic records repository, this project is motivated by the following question:

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context as well the archiving tests that were conducted. The paper concludes with results and conclusions regarding how architectural models and exhibitions designs are archived at USAM.

Relevant Literature

Architectural models and drawings have only recently become objects of scholarly and aesthetic interest to be collected by cultural institutions. As late as 1977, Gebhard and Nevins note that "our present interest in collecting, preserving, and cataloging architectural drawings is in its infancy, and because of this, much of our past—via architectural drawings—is lost forever."[ii] They note that this is particularly problematic because "it can be forcibly argued that the concept of the architect, in many instances, is far better revealed through the drawings than in the executed buildings" for the built object "immediately begins to be modified by nature and by our use of it."[iii] Thus, the designer or architects vision can be "more forcibly asserted through the convention and symbolism employed in drawings than by the actual construction of a project." [iv]

Some of the earliest preservation guidance for archivists with regard to architectural drawings is captured in Society of American Archivists publications such as *Archives and Manuscripts: Maps and Architectural Drawings*. [v] Architectural drawings and maps are grouped together because both are oversized and thus handled differently than most archives and manuscripts. Other significant contributions include articles from *American Archivist*, such as Lathrop's 1980 article, and an entire issue dedicated exclusively to architectural records in 1996. [vi]

More recent contributions from Society of American Archivists publications include Lowell and Nelb's book, *Architectural records: managing design and construction records*. [vii] This is the first manual to directly address CAD records. Lowell and Nelb note that this is needed because "although architects still create some drawings by hand or 'on the boards,' especially those for conceptual design, computer aids are used to generate the majority of designs, drawings, computations, and specifications." [viii] Despite the ubiquity of CAD, they find that "there is a great potential that the records will be lost before the firm needs

to reuse them for the first addition or renovation to a project unless they copy (reformat) them onto the most current storage media." [ix] And although Lowell and Nelb's book is nearly two-hundred pages long, the discussion of CAD preservation is only five pages long (pages 133-138), which indicates that additional research and guidance is needed for archivists interested in preserving and making available architectural drawings and models.

Additional guidance on preserving CAD files was provided by Fallon and Associates in *Collecting, Archiving, and Exhibiting Digital Design Data,* a study commissioned by the Art Institute of Chicago. [x] This report includes very specific guidance, including file naming conventions, use of repository software, and implementation of metadata schemes such as CDWA (Categories for the Description of Works of Art) and Dublin Core. One limitation of this project is that it is over ten years old, so it is useful to consider how well each of the recommendations holds up over time.

More recent projects like MIT's Façade project provide guidance not only for 2D drawings but also for 3D models. [xi] Whereas 2D drawings can be converted into formats well suited for long-term preservation such as PDF/A, 3D models do not have an industry standard format. For 3D models, Smith notes that "native 3D CAD file formats cannot be interpreted accurately in any but the original version of the original software product used to create the model." [xii] Thus, "if the native 3D CAD models are kept, then the proprietary software used to create it must also be archived." [xiii]

The most recent guidance on preserving CAD is provided by Ball in *Preserving Computer-Aided Design*. [xiv] He provides several recommendations, including the notion that "CAD models should be normalized to at least one, and ideally two or three, vendor-neutral, standard formats," and notes "STEP or IFC are ideal." [xv] STEP is short for "Standard for the Exchange of Product Model Data," and is an ISO standard. IFC is short for "Industry Foundation Classes" as is meant to express building information models (BIMs).

As alluded to in the previous paragraph, it is worth noting that architects have begun to move away from CAD and toward BIM, which is short for "Building Information Models." BIM

software, like Autodesk's Revit, provide design and 3D modeling functionality, but also incorporate several other components for structural engineering and building construction. [xvi] Preserving BIM information will not be explored here; however, this is the next technology that should be of interest to those preserving the work of architects.

Study Methods

Context Overview

Before the study is presented, some background on USAM is necessary. USAM collects contemporary and modern art, produces approximately a dozen exhibitions each year, has over 50,000 square feet of gallery space, and welcomes on the order of a million visitors annually. USAM has maintained archives since the 1970s, and currently houses approximately 7,000 cubic feet of paper records. The records include exhibition files, artist files, architectural records and other historical records, and is open to researchers throughout the year on a request basis. The archives is led by a head of library and archives, with a dedicated archivist reporting up to this head.

The bulk of the drawings unearthed during the inventory project were created by exhibition designers, who would use CAD drawings to layout the artworks in the galleries and specify alterations to the gallery, such as artificial walls, paint colors, and equipment installation points. These drawings also include designs of custom-built fixtures needed for a given exhibition, such as vitrines, or other types of support needed to exhibit a given artwork. In some cases, these drawings and models were quite complex, such as in cases where artists were commissioned to create large-scale installations within the museum. In such cases, the artwork was designed and fabricated through the use of these computer-aided drawings and models. The installation of these large-scale artworks necessitate the expertise of structural engineers and leveraging building specifications that would tie into these drawings and models. For example, artworks suspended for the ceiling need to take into account the correct support locations within the building and the amount of weight each of those beams can reasonably hold.

During focus groups, exhibition designers confirmed their reliance on drawings and models. The exhibition management department at USAM includes not only designers both also lighting specialists and fabrication staff, who make the custom cases and other supports needed to exhibit complex artworks. For each exhibition, several sets of drawings are usually created in planning and producing an exhibition. However, “as-installed” drawings are always created which represent how the installation finally came together. Sometimes, problems are encountered during the exhibition planning process and changes need to be made, such as a loan for an artwork falling through. Thus, drawings used during the planning stages may not overlap entirely with the “as-installed” drawings.

In addition to exhibition designs, architectural drawings and models were uncovered during the network storage scan. As USAM has worked with notable architects and firms for projects that have been conceptualized and in some cases built, there is a significant quantity of architectural models available as digital files. This also includes drawings and models for existing buildings with high architectural significance that were created during the course of renovation and restoration projects.

Records Overview

As indicated earlier, the network storage scan revealed extensive use of VectorWorks and its predecessor MiniCad, which is produced by Nemetschek. [xvii] Autodesk AutoCAD drawings were also frequently used, although the 3D modeling program produced by Autodesk (3ds Max) is not frequently used. [xviii] Instead, 3D models are often produced with Rhinoceros 3D modeling software produced by Robert McNeel & Associates. [xix]

2D/3D	Extension	Format	Total Files	Total GB
2D	VWX	VectorWorks CAD format	9,670	65.4 GB
	MCD	MiniCad (predecessor to VectorWorks)	10,221	21.2 GB
	DWG	AutoCAD Drawing	7,293	5.4 GB
	DXF	AutoCAD Drawing Exchange Format	238	0.6 GB
3D	3DM	Rhinoceros 3D Model	6,246	51.8 GB
	Totals:		33,678	144 GB

Table 1. 2D and 3D file formats found from the network scan.

Solution Finding Methodology

For the electronic records repository project, the consultant advocated for the creation of a trusted digital repository (TDR) that would adhere to the Open Archival Information System model (OAIS). The interest here was not having the repository certified as trustworthy, but rather attempting to ensure that most if not all of the attributes were met. A full discussion of TDR and the OAIS model is beyond the scope this paper, background resources can be found in the notes section. [xx]

The software that was explored for managing the repository is Archivematica, which is created by Artefactual Systems. [xxi] Archivematica explicitly implements aspects from the OAIS

model, such as normalizing files that are included in the Submission Information Package (SIP) into formats well suited for long-term preservation for inclusion in the Archival Information Package (AIP). Archivematica also creates files designed for access that can be included in the Dissemination Information Package (DIP). It should be noted that original files are also kept in archival storage and are not discarded in this process. Since CAD files are both complex and uncommon outside of select industries, automatic normalization routines are not available in Archivematica; thus, all files need to be manually normalized for preservation and access.

The format normalization strategies that will be explored and tested included the following:

Extension	Description	Preservation Format	Access Format
DWG	AutoCAD Drawing	Original format	PDF
DXF	AutoCAD Drawing Exchange Format	Original format	PDF
VWX	VectorWorks CAD format	DXF (text-based)	PDF
MCD	MiniCad	DXF (text-based)	PDF
3DM	Rhinoceros	Original Format	Original format, PDF as preview

Table 2. Initial file normalization paths for preservation and access

To test the file normalization paths described in Table 2, ten files of each type were manually normalized to preservation and access formats. Each file was then manually inspected to ensure that all aspects in the original drawing or model are captured in the preservation and access formats.

The files that are of the greatest concern were the VectorWorks and MiniCAD files because backwards compatibility is not assured by Nemetschek. For example, a VectorWorks knowledge base article notes that "Some older file formats are no longer readable by newer versions of Vectorworks regardless of backwards compatibility." [xxii] VectorWorks and MiniCAD are proprietary, binary formats, and no specification for the formats exists outside of the company that produced them. Formats that lend themselves to long-term preservation are often text-based, openly documented, and widely used. Ideally, these VectorWorks and MiniCAD files could be migrated to text-based DXF file formats because this format has been found to be "suitable for preservation" because it is "well supported by other CAD, drawing and even word processing" programs. [xxiii] Converting the VectorWorks drawings to STEP format—as advocated by Ball—was explored however it is not an option in VectorWorks. [xxiv] In an attempt to create the DXF and PDF files, MiniCad and VectorWorks files were converted using VectorWorks 2015.

AutoDesk does not openly specify the DWG file format. However, the Open Design Alliance has created an open specification for the format, and they created the free software Teigha viewer for reading these files. [xxv] Further, AutoDesk makes a free DWG viewer – DWG TrueView. [xxvi] For these reasons, DWG files are deemed suitable for preservation. DWG and DXF files, including those converted from VectorWorks and MiniCAD, were opened with both DWG TrueView and the Open Design Alliance's Teigha viewer to ensure that they render correctly.

PDF access copies will be created for DWG and DXF files using DWG TrueView. A 2D drawing in DWG TrueView is illustrated in Figure 1.

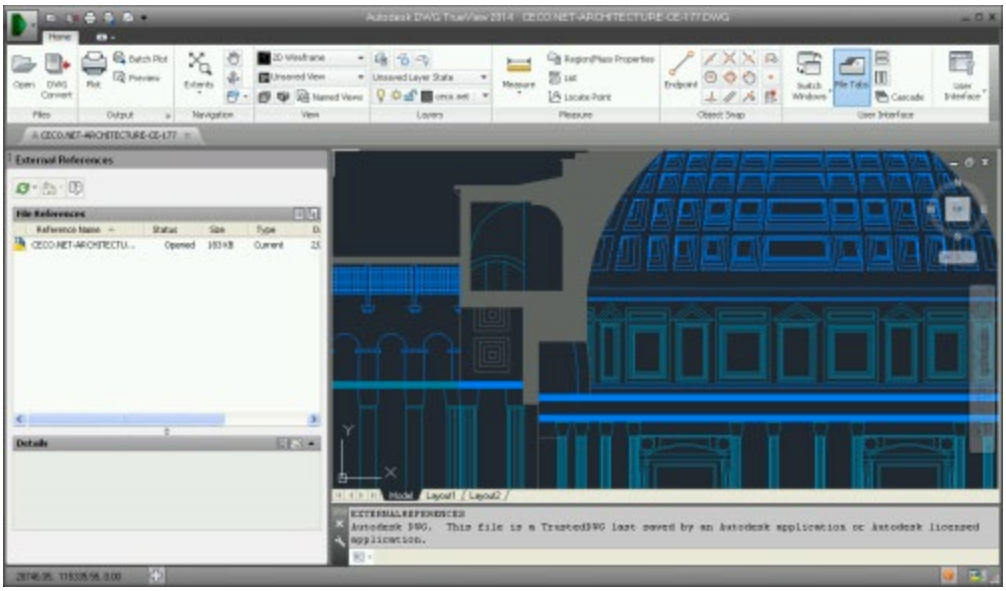

Figure 1. CAD Drawing of the Pantheon in Rome in DWG TrueView

Also of interest are the Rhinoceros 3D models, which cannot be fully used and appreciated as 2D representations. Users should be able to view the model from any angle or perspective that they wish, so flattening a 3D model into a 2D PDF file would be a very diminished representation. Although Acrobat Reader is able to read 3D PDF files, this option was not explored because it would require costly third party software to convert Rhinoceros files to 3D PDF. [xxvii] Despite this, a 2D PDF should be created as a quick reference representation. An example of a 3D model in Rhinoceros in include in Figure 2.

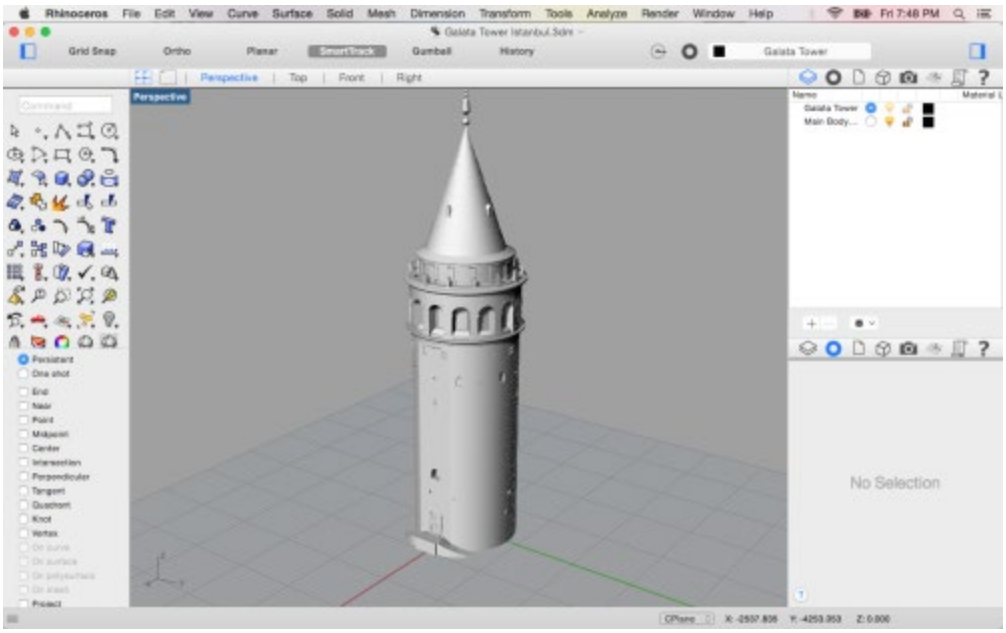

Figure 2. 3D model of the Galata Tower in Istanbul in Rhinoceros

Results

Test conversions of VectorWorks and MiniCad formats to DXF had some success. However, for VectorWorks files that included embedded JPGs, it was reported that, when opened in DWG TrueView as DXF files, the embedded JPGs were illegible. Although the files rendered correctly in the Open Design Alliance's Teigha Viewer, they did not render properly in DWG TrueView. For exhibition designs, representations of artworks as JPGs are often used within the CAD document. However, it was noted that both VectorWorks and MiniCad files, when exported to DWG, opened properly in DWG TrueView, including embedded JPGs. Therefore, because of DWG's ability to more fully represent VectorWorks and MiniCAD, as well as its other advantages discussed earlier, the target perseveration format for VectorWorks and MiniCAD will be DWG. The revised file normalization paths are included in Table 3.

Extension	Description	Preservation Format	Access Format
DWG	AutoCAD Drawing	Original format	PDF
DXF	AutoCAD Drawing Exchange Format	Original format	PDF
VWX	VectorWorks CAD format	DWG	PDF
MCD	MiniCad	DWG	PDF
3DM	Rhinoceros	Original Format	Original format, PDF as preview

Table 3. Revised file normalization paths for preservation and access

It should also be noted that VectorWorks 2015 could successfully open MiniCad files even though some had create date stamps going back to 1999. Further, Teigha Viewer was able to open all DWG and DXF files and they looked exactly like the drawings in DWG TrueView. Despite this, Teigha Viewer for Mac OS X would sometimes crash while zooming in and viewing the model, making DWG True View the preferred viewer for DWG and DXF files.

Creating PDFs using VectorWorks, DWG True View, and Rhinoceros proved unproblematic. For both 2D drawings and 3D models, it is important to setup the current view

and export that as the PDF, so that the exported PDF most fully represents the model or drawing.

Conclusion

The study found that 2D drawings can best be preserved by converting them to the industry standard CAD format: AutoCAD DWG. This format has been openly documented by the Open Design Alliance, can be opened by open-source software, and the manufacturer Autodesk has created free software for viewing files in this format. However, despite attempts by outside groups, AutoDesk does not provide their specification for the file format, and the DWG file format is likely to continue to evolve. [xxviii] For this reason, a copy of DWG True View should be deposited in the digital archives, and new copies should be deposited when significant software or file format changes occur. Although completely open CAD formats do exist, such as the STEP format, the utility of such formats is inhibited by software not being able to export to such formats (in this case, VectorWorks for 2D files).

While conversion of CAD drawings to PDF/A is one approach to preservation, this project found that in many cases, there was information outside of the printed area that would be lost if only information in the printable area was preserved. For example, for exhibition designs, there are sometimes alternative artworks included outside of the print margins that can be swapped in if a particular artwork becomes unavailable for the exhibition. This is interesting information that would have been discarded if only the printable area was preserved.

For 3D models, it is still currently necessary to preserve the original file, as well as the software for reading the model. In this case, Rhinoceros needs to be deposited in the digital archives, and new copies of the software should be deposited when significant file format changes occur. Although 3D PDF is an intriguing option, it requires costly conversion software that was not explored in this project. Presently, both the original file and the modeling software need to be maintained.

Although not covered in this paper, and because of the labor needed to preserve drawings and models (e.g., manually normalizing files, such as creating DWG and PDF files), appraisal of digitally-created architectural models and exhibition designs is necessary. At a minimum, appraisal work would weed-out duplicative material. At a maximum, appraisal could eliminate all but the final drawings and models and discard earlier versions. At USAM, establishing appraisal criteria for drawings and models—as well as other electronic records—continues to be a work in progress, and is an area of future research.

About the Author

Anthony Cocciolo is an Associate Professor at Pratt Institute School of Information and Library Science, where his research and teaching are in the archives area. Prior to Pratt, he was the Head of Technology for the Gottesman Libraries at Teachers College, Columbia University. He completed his doctorate from the Communication, Media and Learning Technologies Design program at Teachers College Columbia University, and BS in Computer Science from the University of California, Riverside. You can find out more about him at his website: http://www.thinkingprojects.org.

Notes:

[i] Anthony Cocciolo, "Challenges to born-digital institutional archiving: the case of a New York art museum," Records Management Journal 24 no. 3 (2014).

[ii] David Gebhard and Deborah Nevins, 200 Years of American architectural drawing (New York: Whitney Library of Design, 1977), 21.

[iii] Gebhard and Nevins, 200 Years, 25.

[iv] Gebhard and Nevins, 200 Years, 25.

[v] Ralph E. Ehrenberg, Archives & Manuscripts: Maps & Drawings (Chicago: Society of American Archivists, 1982).

[vi] Alan K. Lathrop, "The Provenance and Preservation of Architectural Records," American Archivist 43 no. 3 (1980); American Archivist 59 no. 2 (1996).

[vii] Waverly Lowell and Tawny Ryan Nelb, Architectural records: managing design and construction records (Chicago: Society of American Archivists, 2006).

[viii] Lowell and Nelb, Architectural records, 16.

[ix] Lowell and Nelb, Architectural records, 136

[x] Kristine K. Fallon Associates, Collecting, Archiving and Exhibiting Digital Design Data (Chicago: Department of Architecture, Art Institute of Chicago,
2004), http://www.artic.edu/collections/digital-design-data (accessed March 19, 2015).

[xi] MacKenzie Smith, "Future-Proofing Architectural Computer-Aided Design: MIT's FACADE Project," in Architecture and Digital Archives: Architecture in the digital age: a question of memory, ed. David Peyrcé and Florence Wierre (Gollion, Switzerland: InFolio, 2008), 409-423.

[xii] MacKenzie Smith, "Curating Architectural 3D CAD Models," International Journal of Digital Curation 4 no. 1 (2009): 101.
Smith, "Future Proofing," 411.

[xiii] Alex Ball, Preserving Computer-Aided Design (CAD) (Bath, UK: Digital Preservation Coalition, 2013), (accessed April 27,
2015), http://www.dpconline.org/component/docman/doc_download/896-dpctw13-02pdf (accessed April 27, 2015).

[xiv] Ball, Preserving CAD, 29.

[xv] Autodesk Revit: http://www.autodesk.com/products/revit-family/overview

[xvi] VectorWorks: http://www.vectorworks.net/

[xvii] AutoCAD: http://www.autodesk.com/products/autocad/overview

[xviii] Rhinoceros: https://www.rhino3d.com/

[xix] RLG and OCLC. Trusted Digital Repositories: Attributes and Responsibilities (Mountain View, CA: RLG, 2002), http://www.oclc.org/content/dam/research/activities/trustedrep/repositories.pdf (accessed March 19, 2015); OCLC & CRL, Trustworthy Repositories Audit & Certification: Criteria and Checklist (Chicago, IL: CRL and Dublin, OH: OCLC, 2007), http://www.crl.edu/sites/default/files/attachments/pages/trac_0.pdf (accessed March 18, 2015); Brian F. Lavoie, Technology Watch Report: The Open Archival Information System Reference Model: Introductory Guide (Dublin, OH: OCLC and Digital Preservation Coalition, 2004), http://www.dpconline.org/docs/lavoie_OAIS.pdf (accessed March 18, 2015).

[xx] Archivematica: https://ww.archivematica.org/en/

[xxi] VectorWorks Knowledgebase File formats: http://kbase.vectorworks.net/questions/646/File+Formats

[xxii] Keith Westcott, Preservation Handbook: Computer Aided Design (London: Arts and Humanities Data Service, 2005), 3.

[xxiii] VectorWorks 2015 supports export to STEP for only 3D files, not 2D files.

[xxiv] Open Design Specification for .DWG files: http://opendesign.com/files/guestdownloads/OpenDesign_Specification_for_.dwg_files.pdf; Open Design Alliance

[xxv] Teigha Viewer: http://www.opendesign.com/guestfiles/teigha_viewer

[xxvi] AutoDesk DWG TrueView: http://www.autodesk.com/products/dwg/viewers

[xxvii] 3D PDF Exporter for Rhino: http://www.rhino3d.com/resources/?id=4673

[xxviii] Autodesk: DWG File format change: http://knowledge.autodesk.com/support/autocad-architecture/troubleshooting/caas/sfdcarticles/sfdcarticles/DWG-file-format-change.html