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Preserving Born-Digital Design and Construction Records

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**DPC Technology Watch
Report**

December 2021



Digital Preservation Coalition

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Foreword

The Digital Preservation Coalition (DPC) is an advocate and catalyst for digital preservation, ensuring our members can deliver resilient long-term access to digital content and services. It is a not-for-profit membership organization whose primary objective is to raise awareness of the importance of the preservation of digital material and the attendant strategic, cultural and technological issues. It supports its members through knowledge exchange, capacity building, assurance, advocacy and partnership. The DPC's vision is to make our digital memory accessible tomorrow.

The *DPC Technology Watch Reports* identify, delineate, monitor, and address topics that have a major bearing on ensuring our collected digital memory will be available tomorrow. They provide an advanced introduction in order to support those charged with ensuring a robust digital memory, and they are of general interest to a wide and international audience with interests in computing, information management, collections management and technology. The reports are commissioned after consultation among DPC members about shared priorities and challenges; they are commissioned from experts; and they are thoroughly scrutinized by peers before being released. The authors are asked to provide reports that are informed, current, concise and balanced; that lower the barriers to participation in digital preservation; and that they are of wide utility. The reports are a distinctive and lasting contribution to the dissemination of good practice in digital preservation.

This report was written by Aliza Leventhal, Head of the Technical Services Section of the Prints and Photographs Division at the Library of Congress, and Jody Thompson, Head of the Archives, Special Collections and Digital Curation department for Georgia Institute of Technology. The report is published by the DPC in association with the UK Nuclear Decommissioning Authority. Thanks to the DPC editorial board and peer reviewers, with special thanks to Alexandra Jokinen.

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Aliza Leventhal, Library of Congress
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1 Executive Summary

This report aims to support archival professionals, as well as active designers and facilities managers, considering acquisition, preservation, and access approaches that account for both the technical and cultural components of the broad range of born-digital design and construction records created throughout the course of designing, building, and maintaining a built space.

The evolution of software ecosystems within architecture, design, and engineering professions has led to steep learning curves on a wide range of topics, including the changing relationships between designers, their tools, and their outputs, as well as prompting an iterative adoption process as technology catches up with initial innovative ideas. The variety of software and potential uses strains a repository's capacity to determine the best preservation approach for these files, because this determination is dependent on understanding the intent and actual use of software by a firm or individual designer or engineer.

To address building a repository's capacity to steward these records, this report covers the development of digital visual literacy to understand the information rendered in born-digital design files, and the functionality the rendering software supports to facilitate accessing the files in the future. It also describes the need for establishing comfort levels with data loss, and balancing limitations in resources of staff expertise, time, technology, and funding with anticipated access needs. Through case studies from mostly United States (US)-based repositories, different approaches to acquisition, description, preservation, and access to these records are explored. Additionally, this report describes key initiatives undertaken by the archival community over the past 25 years that recount the challenges and accomplishments associated with the life cycles of born-digital design and construction records. Building upon those key initiatives, the current activities and resources section provides a window into trends in design software features and uses by design firms and regulated industry, and highlights potential challenges for archival professionals to address. Recognizing the ongoing challenges for repositories to transition their workflows for paper-based collections of design and construction records to born-digital design and construction records, this report offers a realistic outlook for repositories of varying levels of resources, staff expertise, collecting scopes, and researcher expectations.

2 Abstract

Born-digital design and construction records encompass a wide range of content, from initial design sketches to robust Building Information Models (BIM) that represent the connections and dependencies of complex built spaces. The broad range of communication intention and levels of granularity in these files hold the keys to understanding theoretical and tangible built spaces, and contain both visual representations and critical data about projects and the software used. Appreciation of these aspects will aid the archival professional in the acquisition, processing, preservation, and access of these complex files. This report primarily addresses concerns of archival professionals and repositories collecting design and construction records, as well as engaging with the creators of these records. Beginning with a brief introduction to the evolution of the design software landscape and core concepts of visual literacy, it outlines notable archival initiatives of the past 25 years. The report also offers case studies presenting a variety of potential collecting institutions' considerations from repositories based in the US. It concludes with guidance for future research, and brings together resources and recommendations for collecting and contextualizing born-digital design records, despite the current lack of universally acceptable workflows beyond standard digital preservation practices.

3 The Evolution of Born-Digital Design

Design and construction records bridge the worlds of art and technical practicality, often the bricolage by-product of creators using every tool at their disposal to communicate their design or assembly intent most effectively. The visual and data information (such as drawings and models) communicated in these records has continued to increase in complexity with the introduction of computers to design and construction disciplines, further compounded as the ecosystem of potential tools has fluctuated and changed rapidly over the past 40 years. With the added technological aspects of born-digital design and construction records, namely the heavy reliance on proprietary software that is perpetually updating with new patches and version releases, it is critical to contextualize the creation and use of these records to effectively appraise and ensure integrity for long-term access. Through a proactive and iterative approach, archival professionals and stewards of born-digital design and construction records can not only document the ecosystem of software used by a creator, but also understand the core features and crucial information stored by various files related to a single project. Developing a level of visual literacy for both the artistic and technical documentation, as well as a digital visual literacy to understand the rendering environment of these files, is necessary for the success of long-term access options such as emulation (the use of an application program or device to imitate the behaviour of another program or device).

Design records are the by-product of artistic and technical communication efforts that continue to evolve as new techniques and tools, including software, have been introduced and adopted by architecture, design, and engineering professionals. Over the course of 60 years, from Ivan Sutherland's invention of Sketchpad in 1963, and the first release of AutoCAD in 1982 ([Hurley](#), n.d.), design software has blended the aesthetic and technical components required to envision and implement plans for the built environment. This blending of information produces complex records that are multipurpose in communication intent, and also multifunctional, with dynamic features for creators and potential audiences to engage and explore a proposed design or actual built space. This added complexity presents a higher barrier for archival professionals (and most non-design professionals generally) from engaging in collection, preservation, and access activities for these records.

Visual literacy, technical literacy, digital literacy, and a level of familiarity with the design process all facilitate a viewer's ability to interpret the intention, identify the explicit information, and appreciate the supporting information (such as metadata or supporting algorithms to generate a display) that comprise a born-digital design and construction file. Acknowledging the continuously changing landscape of technology used by architecture, design, and engineering disciplines, it is clear that maintaining awareness of future born-digital design and construction records to collect is critical. The fact that this must be done in tandem with learning about historic software and architecture, design, and engineering practices is a tall order to ask of archival professionals, and especially so for repositories that do not have architecture, design, and engineering collections as their primary focus. Almost every repository type collects architecture, design, and engineering records for at least their immediate facilities maintenance purposes. The ubiquity of these records necessitates all repositories to plan for the eventual collection of born-digital design and construction records, regardless of the level of intensity of their program ([Lindlar](#), 2020).

3.1 Visual Literacy and Digital Visual Literacy

Visual literacy is defined by John Debes, founder of the International Visual Literacy Association, as 'a group of vision-competencies a human being can develop by seeing and at the same time having and integrating other sensory experiences' ([Debes](#), 1969). Since then, several disciplines have offered varying interpretations and definitions to emphasize the foci or contributions of a particular

discipline. To this end, the Association of College and Research Libraries (ACRL) has created 'Visual Literacy Competency Standards for Higher Education' ([ACRL, 2011](#)), and the Art Libraries Society of North America has core competencies for several design disciplines including architecture, graphic design, and landscape architecture ([ARLIS/NA, 2021](#)). Each of these resources provides a helpful framework for the visual and contextual elements needed to develop visual literacy fluencies for specific disciplines. Building upon that foundation, two articles written for the archival profession 'Behind the Image' ([Collins, Collins and Garnaut, 2007](#)) and 'Of Grasshoppers and Rhinos: A visual literacy approach to born-digital design records' ([Leventhal, Collins and Walsh, 2021](#)) offer detailed discussions of practical steps towards understanding the explicit and tacit information represented in traditional paper-based records from architecture, design, and engineering professions and born-digital design records, respectively. While these two articles offer very similar advice generally, 'Of Grasshoppers and Rhinos' argues that both the files and the software interface are equally relevant to seeing, reading, and interpreting the information a born-digital design file contains.

The inclusion of the creation process, especially in software form, requires a reader or user of born-digital design records to understand an additional layer of context, as well as to develop technical competencies. In other words, a digital visual literacy is required for archival professionals, future researchers, and facilities managers to fully engage with and understand the information born-digital design records contain. Digital visual literacy is the ability both to create and to understand visual materials created with a computer ([Spalter and van Dam, 2008](#)). The development of this competency is further complicated by the breadth of software available and in use by designers, as well as the ever-updating software versions ([Allen, 2016](#)). This digital visual literacy is part of a tacit skill set developed during a designer's academic and professional experience as 'computationally-generated imagery has become a new vernacular language of architectural representation' ([Llach and Donaldson, 2021](#)). That said, there is a steep learning curve for archival professionals and potential researchers who have not completed academic design programs or worked in design professions.

This fluidly evolving software ecosystem raises the barrier to engagement to an intimidating level for archival repositories that are already reconciling budgetary and staff resources. Recommended Formats Statements from the United Kingdom Data Services ([UK Data Services, 2021](#)), the Library of Congress ([Library of Congress, n.d.](#)), the US National Archives and Records Administration ([NARA, 2020](#)), and Drexel University ([Drexel University, n.d.](#)), to name a few, have expanded in recent years to include guidance for repositories that collect design and 3D file formats. These statements reflect consideration for the more established and sustainable file formats, and acknowledge the prevalence of file formats produced by vendors with notable market presence, including Autodesk, Trimble, Bentley Systems, and Dassault Systems ([Markets, 2021](#)). With this guidance, collecting repositories with narrower design record collecting scopes, often focused on their campus or individual structures, can more effectively articulate their information and functionality needs from the born-digital design files in their custody. A clearer understanding of a repository's collecting scope and access expectations can help frame the level of digital visual literacy needed, which can, and should, be scalable from facilities management to the more experimental and design process-oriented collections (for example, the Canadian Centre for Architecture's (CCA) *Archaeology of the Digital* ([CCA, 2016](#)), or the Het Nieuwe Instituut's MVRDV Archive ([Het Nieuwe Instituut, 2016](#))). It is therefore critical to set a sliding scale of reasonable expectations for archival repositories to preserve the full spectrum of the design process and documentation of the built environment. In practice, this means many collecting repositories will be able to fulfil their designated community's needs by offering a static representation (such as Portable Document Format (PDF)) of born-digital design files; for example, a full set of schematic, development, and construction drawings that would be prepared for printing in the course of the design process, rather than needing to support dynamic access through original software facilitated by emulation or free viewer platforms ([Autodesk, n.d.a](#)).

3.2 Brief History of Computer Use in Design Disciplines

There is a tradition of experimentation with tools as part of the design process, resulting in the broad adoption of technological innovations from the cyanotype print (blueprints) in the mid-1800s to computers in the 1960s. With the advent of the computer, a critical symbiotic relationship developed between the fields of architecture and design and computer science. A thorough overview of this parallel development was discussed at the opening session 'ADE Formats Primer' of the 2017 *Designing the Future Landscape: Digital Architecture, Design and Engineering Assets* summit hosted by the Library of Congress, the National Gallery of Art, and the Architect of the Capitol ([Library of Congress](#), 2018). A few key moments in the history of technological innovation and the adoption of computers within design disciplines (namely architecture) are worth further elaboration.

The 1960s provided the initial proof of concept and opportunities for leveraging computers to support design processes, notably Ivan Sutherland's 'Sketchpad' (1963) ([Sketchpad](#), 2019) and Steven A. Coons' 'Coons Patch' (1967) ([Coons](#), 1967), which presented the first instances of computer graphics programs that demonstrated how computers could aid the design process. Shortly after these two programs were published, the 1968 Computer Society's Fall Joint Computer Conference organized by the Association for Computing Machinery/Institute of Electrical and Electronics Engineers (ACM/IEEE) hosted what is colloquially referred to as 'The Mother of All Demos' ([Edwards](#), 2008). In this demonstration, Douglas Engelbart previewed almost all the fundamental elements of modern personal computing from windows, hypertext, and graphics, to video conferencing, dynamic file linking, revision control, and real-time collaborative work ([Ibid](#), 2008).

In the 1970s, the seminal text *A Pattern Language* (Alexander, Ishikawa and Silverstein, Jacobon, Fiksdahl-King, and Angel, 1977) by a group of authors from the Center for Environmental Structure of Berkeley, California, offered a logic of architecture that made sense to non-architects as well as a pervasive framework for our digital lives (Wright Steenson, 2017, p.22). While this contribution from Alexander *et al.* has been inconsistently valued within architecture and design disciplines, it has remained integral to the computer science discipline and software industry. Furthermore, residual impacts of this work can be seen in the development of parametric and generative design programs that create design options from a set of values around room sizes, access to natural light, and desired spatial adjacencies.

Although a few commercial Computer-Aided Design (CAD) programs were available in the 1970s, it was not until the 1980s and 1990s that the rise in availability of 32-bit operating systems allowed for the rapid adoption of computers, and thereby design software ([Leventhal](#), 2018, p.9). During these two decades, architecture, design, and engineering practitioners pushed the limits of what available software could facilitate, occasionally 'breaking' (a colloquial term for hacking or cracking software) the licensed software to develop new features, many of which have been incorporated into more mainstream software over time. This breaking has also been embraced by software vendors, incorporating visual scripting programs (such as Grasshopper, [Robert McNeel & Associates](#), n.d.; or Dynamo, [Dynamo BIM](#), n.d.) into the design software ecosystem, both lowering the barrier to customization and establishing more replicable and stable outputs. Since the mid-1990s there has been a burgeoning market for design software, ranging from purpose-specific software such as Kangaroo3D ([Kangaroo3d](#), n.d.), an interactive physics and constraint solver built with specific software plugin capabilities first released in 2011, to comprehensive programs such as Autodesk's Revit ([Autodesk](#), n.d.b). The multidisciplinary BIM software, intended to coordinate multiple-authored designs, was first released in 2000 and has grown in adoption throughout this century. Comprehending the history of this broad and rich ecosystem is challenging, making resources such

as the Architecture Software Timeline's illustration in the exhibition catalogue of the Architekturmuseum der Technischen Universität München's 2020 *The Architecture Machine* (Fankhänel and Lepik, 2020, p.228–229) incredibly helpful (see Figure 1).

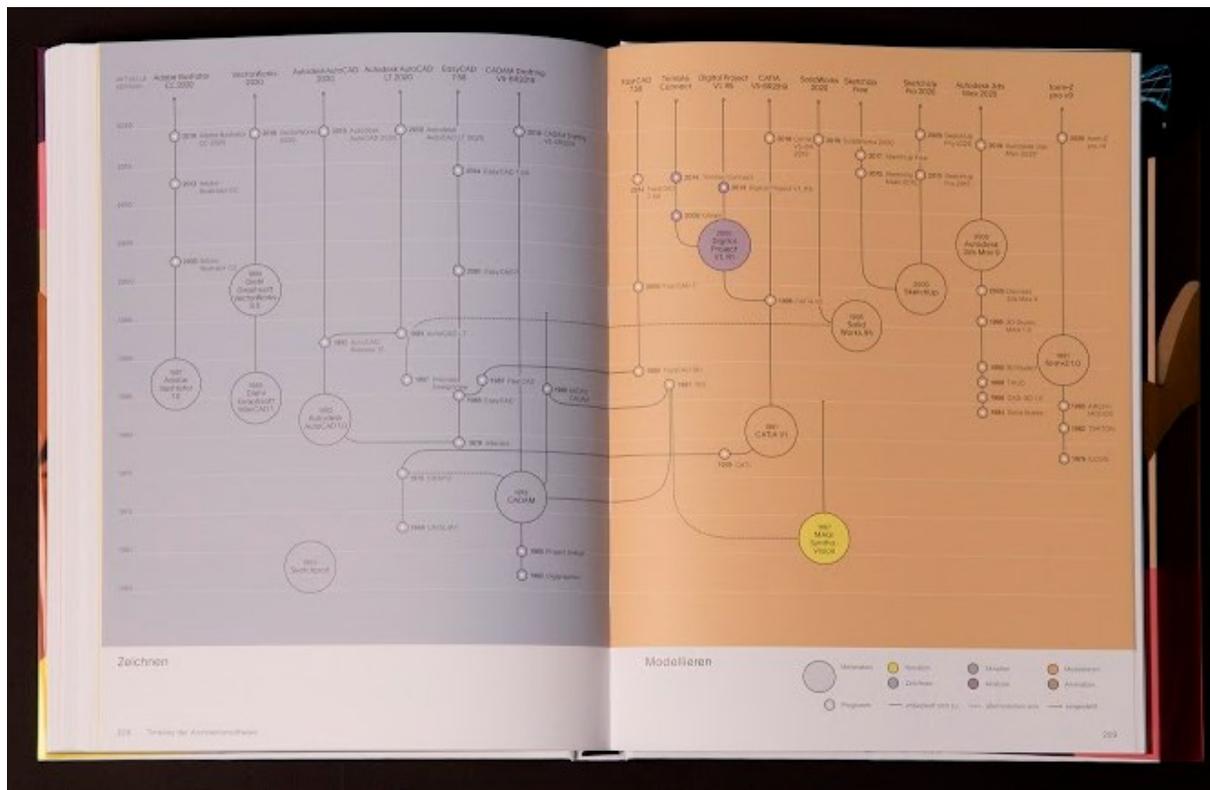


Figure 1. The Architecture Software Timeline's illustration in the exhibition catalogue of the Architekturmuseum der Technischen Universität München's 2020 *The Architecture Machine* (Fankhänel and Lepik, 2020, p.228–229)

3.3 Acknowledging and Preventing Loss

Data degradation, also known as bit rot, is a well-documented risk to digital data and records ([Digital Preservation Coalition](#), 2016). Bit-level preservation is the cornerstone of many repositories' digital preservation strategies, ensuring current and future access to authentic and accurate copies of digital content. 'Maintaining the original bitstream allows for maximum variability for the future, since we do not know the full extent of future use and processing. Bit-level preservation alone, however, does not ensure that content is fully usable in the many ways that users may want to interact with it' ([Library of Congress](#), n.d.a). While there are established workflows to prevent file degradation, such as saving multiple copies of digital files or data to various locations, conducting integrity or fixity checks, creating checksums, and investing in digital repositories to automate and monitor for file degradation, there still are external factors that can result in information loss for born-digital design records.

In addition to the universal bit-level preservation concerns, the three major risks of loss for born-digital design records are:

- availability of original software versions that produced the files.
- missing support files, accompanying metadata, and/or broken or lost links to external reference files when born-digital design records are transferred from a record creator to an archival institution.

- understanding how the nuances of the iterative design process are reflected in a project's born-digital design files, including the multiple uses of design software and varying practices of design professionals or a firm across projects.

Significant progress has been made on resolving the issues of access to functional versions of original software used to create born-digital design records from the late 1980s through the early 2000s. Most notable is the development of emulation infrastructure and collecting of design software, such as the Oliver Witte American Institute of Architecture software collection imaged by the CCA. This is also expected to be available through Emulation as a Service Infrastructure (EaaS) in the near future. Additionally, Autodesk has expanded access for active users from three to five previous versions of their software, responding to a direct request from their user community. This is one of the most explicit acknowledgments of versioning concerns by a vendor ([Autodesk, 2020a](#)). However, not all software vendors have provided additional access to older versions of their software or ensured backwards and forwards compatibility for their files. In such instances, creative problem solving and cross-discipline collaboration are crucial in utilizing a designer's expert knowledge, which may include personally saved older versions of software, to navigate older files, and properly forward-migrate files to versions that are accessible by the most current versions. This type of case-by-case support enables archival professionals to facilitate further migration and to exchange and/or preserve formats to ensure the design content remains accessible even after the originating software is no longer available. As with any proprietary and copyrighted material, repositories must follow the legal framework of the country in which they operate. However, this may restrict a repository's potential to leverage developing preservation and access technology. Archival advocacy, such as the Software Preservation Network's Code of Best Practices for Fair Use in Software Preservation ([Cox, Aufderheide, Jaszi, Butler, 2019](#)), is the type of resource that will continue to develop and prompt important conversations on national and international levels.

The issue of proper transfer and inclusion of all support files and documentation requires proactive conversations and cooperation of donors and depositors. Common support files to be aware of are: custom fonts and line types or weights ([Autodesk Knowledge Network, 2020](#)) that indicate properties of the design; external reference files (xrefs) to local libraries of textures; and commonly used elements or families (for example window or door assemblies) ([Aubin, 2021](#)). Leveraging established documentation such as the Deed of Gift, as well as conducting more in-depth donor interviews about their technical infrastructure, and digital preservation workflow resources such as the CCA's Digital Archives Processing Manual ([CCA, n.d.a](#)), better prepares archival professionals and collecting repositories to account for previously overlooked files or metadata with information that supports functionality, data, and display of born-digital design records. Despite best efforts to capture contextualizing information and identify dependency files, there is still a high probability of some metadata loss due to a mixture of continuously updating software and underlying computing issues such as a short network disconnection while saving a file. Many of these issues have been addressed by software vendors (for example, [Autodesk Knowledge Network, 2021](#)), but due to the substantial delay between the time a file is created and when it comes to the repository, potentially minor corruptions and misplaced files become a compounded issue to resolve, especially at large scale.

Building upon conversations with donors for the transfer of design files and their related support files, archival professionals also need to learn about the workflows and intended use of design software and their outputs at different points in the design process. The *Design Methodology* portion of the CCA's 'Submission of Digital Files Questionnaire' offers a helpful framework to prompt donors to describe the software used at different phases of design (Winn and Williams, Eds., forthcoming, Module 26 Appendix C 'Submission of Digital Files Questionnaire'), but additional context is often required to account for changes in practice as new software enters a design professional's or a firm's software ecosystem, or as those software themselves evolve to support

new functionality. The addition of Dynamo as a visual scripting language for Revit, for example, presents new opportunities that might have previously been conducted using the Grasshopper visual scripting program's plugin to Rhino. 'Software selection affects design outcome' ([Serriano, 2003](#)), but as a mostly intuitive or tacit decision-making process it is critical for archival professionals to document and understand the preferences and processes of a design professional. This will help to clarify the intent of design files, as well as disambiguate the role of software throughout the phases of a design project.

4 Key Initiatives

The key initiatives in this section represent what has already been accomplished over the last 25 years and highlight the challenges and achievements associated with the acquisition, preservation, and access of born-digital design and construction records. This selective chronology of publications, exhibitions, seminars, and conferences demonstrates how the research and experience of archival professionals can build as a palimpsest of, and offer next steps for developing, best practices and standards for these complex born-digital files.

4.1 Society of American Archivists' 1996 *American Archivist* issue

In 1996, the Society of American Archivists (SAA) devoted an entire volume of *American Archivist* to design and construction records, focusing on research articles and case studies relevant to the field at that time. These articles described the need for a robust appraisal and selection process; however, a notable article by William Mitchell described the complex problems with digital design files. Even as a user and creator of digital files, he recognized the challenges archival professionals would face with the software, storage, and transfer of these files, and the importance of developing strategies to manage the issue ([Mitchell](#), 1996). Also featured in the issue was Nicholas Olsberg's documentation of the 1994 'Working Conference on Establishing Principles for the Appraisal and Selection of Architectural Records'. At the conference, representatives from a variety of professions, including archivists, curators, and other user-groups of architectural records (such as lawyers, working historians, and librarians), came together to share their individual requirements and perspectives. The result was a thorough understanding of the need for robust selection and appraisal guidelines focusing on fragility, massive amounts of materials, and 'unwieldy scale' (SAA, 1996, p.129). The importance of having such wide-ranging representation at the conference was also recognized by all attendees.

4.2 Chicago Institute of Art

To assist repositories with technological solutions, standards, and workflow processes for the preservation of digital and paper design files, Kristine Fallon Associates, Inc. (an information technology consulting firm for design, construction, and facility management) and the Department of Architecture and Design at the Art Institute of Chicago published the study *Collecting, Archiving, and Exhibiting Digital Design Data*. Over 100 architecture firms, mainly in North America, participated in case studies to determine the software and tools commonly used in the design process. Experts from archival and cultural institutions were surveyed and brought in to brainstorm the best methods for managing and preserving the files. Recommendations for repositories managing digital design records, both born-digital and digitized, were based on a two-tiered collection approach. The first tier, comprised of native files, was preserved only at the bit-level; the second tier, consisting of digitized files, was recommended for preservation only as PDFs and Tagged Image File Formats (TIFF) (Kristine Fallon Associates Inc., 2004). The tiered approach will be described in more detail with case studies in SAA's forthcoming *Trends in Archival Practice* series on Emerging Best Practices for Born-Digital Design Records (Winn and Williams, Eds, forthcoming).

4.3 FACADE 2006

With the support of an Institute of Museum and Library Services (IMLS) grant, Massachusetts Institute of Technology (MIT) Libraries investigated the complex nature of born-digital design files during the acquisition, appraisal, description, preservation, and access phases in the Future-proofing Architectural Computer-Aided Design (FACADE) project. With collaboration from MIT faculty in the

School of Architecture and Planning, the team tested the preservation of born-digital design records using the repository software DSpace with data from building projects of select firms, mainly focusing on 3D models and their relationship with 2D drawings, emails, and BIM. One of the deliverables for the project was the development of a project information model (PIM), or relationship map. The PIM covered all types of file formats, from simple text and spreadsheet files (such as Word Document .DOC, and Excel .XSLX) to more complex drawing and geospatial vector data formats (such as AutoCAD or Microstation.DWG, or Shapefile.SHP). This proved useful as it created design workflows for the team. Other proposed deliverables for the project included the Curators' Workbench (CWB), a web-based tool used for creating and processing the metadata for architectural files through a web-based user interface ([Smith, 2009](#)), the development of which would be attempted several years later in FACADE2 (See Section 4.6).

4.4 Architecture and Digital Archives, Architecture in the Digital Age: A Question of Memory Publication

Due to a multi-institution collaboration on architectural repositories, in 2007 the first international conference on preservation and access of architectural digital files was attended by archival professionals, architectural historians, and technologists from Europe, Canada, and the US. From that meeting, *Architecture and Digital Archives, Architecture in the Digital Age: A Question of Memory* ([Peyceré and Wierre, 2008](#)) was published and edited by David Peyceré and Florence Wierre. Case studies explored numerous issues related to the creation and preservation of born-digital architectural records, including initial record creation and re-use by the creator; appraisal and preservation within the repository; and use by researchers. Key takeaways within the book are the need for creators and designers to take an active role in determining which files to preserve and donate to a repository. Some of the archival institution case studies acknowledged the complexities of AutoCAD and other formats, and recommended preserving only DWGs and PDFs due to complications and continual development of the files. As previously mentioned, the investment for archival professionals to remain abreast of the changing landscape of design software and file types is substantial.

4.5 Digital Design Records Task Force

Started in 2012 at the Architectural Records Roundtable meeting during SAA's annual conference, the Digital Design Records Taskforce (DDRTF, formerly CAD/BIM Taskforce) took up the call-to-action of unpacking the relatively unknown complexities of born-digital design files for the American archival community. Aliza Leventhal and Ines Zalduendo served as the initial co-chairs and published an annotated bibliography of previously conducted research and projects from 2000 to 2013, subsequently presented at the Royal Institute of British Architects ([Zalduendo, 2013](#)) and the Society of Imaging Science and Technology Archiving ([Leventhal, 2013](#)) conferences in 2013. From that foundation, the DDRTF explored a myriad of issues from developing profiles of predominant born-digital design file types and making a push for institutions to submit file types to registries like PRONOM ([National Archives, n.d.](#)), to evaluating Deeds of Gift as an outlet for future-proofing collecting of born-digital design records ([Leventhal, Schroffel, and Thompson, 2019](#)), and providing a framework for describing born-digital records in architectural collections ([Leventhal et al., 2020](#)). This work continues as the membership of the DDRTF fluctuates and grows to include archival professionals from corporate, government, academic, and facilities-oriented repositories. This well-rounded group of perspectives, and an ongoing open dialogue with the Design Records Section's steering committee, give the DDRTF confidence that it is addressing the concerns and needs of its

colleagues. Under the leadership of this report's authors, current efforts include creating appraisal tools for several institution types, exploring software tutorials to provide archivists with a foundation in software navigation and functionality, and developing an annotated bibliography of resources around the development and use of design software.

4.6 FACADE2

In 2012, the FACADE2 project was established through a partnership between MIT Libraries and the Frances Loeb Libraries at Harvard University's Graduate School of Design as a continuation of the original FACADE project from 2006. The collaboration focused on upgrading the original CWB by expanding its vocabulary and testing the tool across the two institutions. While software development teams continued to develop and debug the early iteration of CWB, the functionality issues were not resolved before the project's deadline ([Harvard Library Lab](#), 2011).

4.7 Digital Preservation Coalition's CAD Technology Watch Report

Alex Ball's seminal work *Preserving Computer-Aided Design (CAD)*, published by the DPC in April 2013, provides an overview of CAD technologies and the growing number of associated preservation concerns, such as the lack of interoperability between the CAD system and outdated file formats due to the fast pace of software versioning. Ball presents historical and ongoing standardization work and other techniques used to overcome these issues, yet recognizes that there is no one-size-fits-all solution to the preservation of CAD models ([Ball](#), 2013, p. 25). Some recommendations offered in the report include preserving the original CAD model through software emulation, ingesting a 'vendor-neutral, standard file format' ([Ibid](#), 2013, p. 26), and creating a much-needed advocacy group for support around standardization of formats in CAD systems.

4.8 Durable Architectural Knowledge (DURAARK) Project

Starting in 2013, this three-year European Union-funded project recommended methods for sustainable and long-term born-digital design files, including 3D data and BIM models, their associated metadata, related knowledge and web data. Through multiple research paths, supported by a diverse group of stakeholders from different disciplines (including the archival and design communities), requirements and limitations of born-digital design files were identified, including technical failures. Addressing some of these issues, the project developed a holistic digital preservation approach that would leverage a 'semantic digital archive' to 'serve as a central knowledge base for contextual knowledge in the form of structured data about architectural structures' ([Lindlar and Saemann](#), 2014).

4.9 Archaeology of the Digital

In 2013, CCA began a multi-year research project, *Archaeology of the Digital*, consisting of three museum exhibits, two books, and multiple e-publications, which centred around more than 25 projects by key designers such as Frank Gehry and Chuck Hoberman. Curated by architect Greg Lynn, the overarching theme of the project was to explore the history of born-digital design and design technologies within architectural practice, and to address the challenges of preserving born-digital design files for the long term ([CCA](#), 2016).

4.10 Designing the Future Landscape: Digital Architecture, Design and Engineering Assets Summit

Over the course of two days in 2017, *Designing the Future Landscape: Digital Architecture, Design and Engineering Assets Summit* brought together architecture, design, and engineering professionals to explore the issues and challenges with the long-term preservation of, and access to, born-digital design files. Sessions on the first day offered an opportunity for a diverse group of stakeholders, both presenters and attendees, to discuss the history, lessons learned, knowledge transfer, current research, future use, and most importantly, viable solutions to move forward in collecting, preserving, and providing access to born-digital design records. The second day consisted of a workshop, attended by a smaller group of invited attendees and presenters, which resulted in a recognition that more collaboration was needed, particularly within the digital preservation community and design archives. The report of the proceedings referred to the summit as a ‘call to action’ ([Leventhal, 2018, p.5](#)), as it served as a model for the stakeholders to begin to take steps to improve and ensure long-term preservation and access to born-digital design files, and offered potential opportunities for collaborations ([Ibid, 2018](#)).

4.11 Building for Tomorrow

Adding to the collaborative work of the 2017 *Designing the Future Landscape Summit*, the Loeb Library at Harvard University’s Graduate School of Design received a IMLS grant to host a two-day event, bringing together a group of archivists, architects, architectural historians, technologists, and digital preservationists. This interdisciplinary group of stakeholders sought to create an infrastructure for the preservation of digital architectural design and engineering records. The first day, the group discussed barriers, issues, needs, and priorities to develop a shared infrastructure, as well as ways to bring in members of the design community as partners. Topics discussed included working with donors of the records, understanding the software used, making the records accessible for researchers, and dealing with intellectual property concerns. The second day advanced the work, as the stakeholders developed strategies and actions for the creation of a community-driven infrastructure. Some of the ideas explored included producing a business case for building preservation practices within firms, as well as ways to connect various stakeholders. From this two-day meeting, it became clear that all stakeholders need to remain part of an ongoing conversation in order to maintain a well-rounded perspective of the community and its preservation needs. It was also agreed that collaboration should continue without duplicating the efforts of past initiatives. Work on the infrastructure project made headway with presentations and pilot projects starting in 2019 and 2020 and set to conclude in 2021 ([Harvard University Graduate School of Design, n.d.](#)).

4.12 Archiving Digital Architecture Records: National Framework Trial

In 2019 an Australian-based project team consisting of Christine Garnaunt, Julie Collins, and Chris Burns partnered with National Building Specification, icam Australasia, and the Architecture Museum to develop a trial learning experience that focused on the preservation of born-digital design records. This built upon the team’s initial scope of work from 2015 to 2018 that focused on securing and enabling access to knowledge for the future ‘archiving digital architectural records’ (ADAR), and the conversations from a 2016 two-day symposium *Born digital: a symposium exploring digital architectural and built environment records*. The 2019 framework trial included podcasts, videos, and learning exercises for designers and archival professionals. Topics included digital assessment management tools and records retention and disposal guidelines. The trial described to the participants the need for long-term preservation and the development of related best practice. The project team received feedback from the participants on enhancements and future use for the teaching modules. Some designers suggested using a teaching module for continuing education and

professional development, potentially offered alongside a recognized professional institute ([Burns, 2019](#)).

4.13 Digital Preservation Coalition's *Building a Digital Future: Challenges and Solutions for Preserving 3D Models*

In 2020 the Digital Preservation Coalition hosted a one-day virtual event in association with the UK Nuclear Decommissioning Authority. *Building a Digital Future: Challenges and Solutions for Preserving 3D Models*, used case studies, panel discussion, and a Q&A session to focus on the challenges around preserving 3D born-digital design files. Speakers from a variety of European and North American institutions presented on their work, covering a range of topics including collection scope, file formats and their uses, challenges faced, and lessons learned. Case studies presented at the event included Historic England's work with geospatial surveys to digitally preserve heritage sites, a presentation from Radioactive Waste Management on the challenges of preserving digital twins for a Geological Disposal Facility, a software engineer's overview of Autodesk in the preservation of 3D models, as well as the Leibniz Information Centre for Science and Technology's scalable solutions for metadata applied to a variety of 3D modelling formats including BIM ([Digital Preservation Coalition, 2020](#)).

4.14 Digital Architectural Archives Collections: Expanding Practices and Future Uses

Intended originally as a session for the International Confederation of Architecture Museums' (ICAM) conference in 2020, the session was changed to a public online event in December 2020 after the conference was postponed due to the COVID19 pandemic. Co-hosted by the Library of Congress and ICAM, this session explored the opportunities and challenges born-digital design files present for collecting, accessing as research, and exhibiting. Four presentations from the critical perspectives of technologists, curators, academics, and archival professionals sought to establish a shared foundation for the conference attendees to participate in theoretical and practical discussions ranging from visual literacy of born-digital design files to exhibition description practices and appraisal priorities for collecting institutions. To add perspective of the breadth of reach of this event and interest in the topics covered, 174 attendees of the session joined from 22 countries spanning at least 11 time zones during the live event ([Library of Congress, 2021](#)).

4.15 Society of American Archivists' 2021 *American Archivist* special issue on design records

Like the 1996 *American Archivist* issue on design records, SAA devoted a special section to the design field in 2021. Within this section, the authors share their experiences and expertise through case studies, developing resources, and sharing pedagogical models for appraising, processing, describing, digitizing, and teaching with design records both analogue and digital. Case studies covered a variety of efforts including using architecture records for research purposes, establishing and implementing workflows for arrangement and description of a born-digital design collection, as well as recounting the successes and challenges of a mass digitization project. The section also offers guidance for archival professionals in the form of an appraisal tool for discussions with potential donors and designers and guidance for developing digital visual literacy for born-digital records. Teaching with design collections is also a topic discussed to highlight the pedagogical models used at two institutions. A notable takeaway from this special section is the broader benefit to the archival

community in discussions taking place around this seemingly niche record type, despite most archival professionals not identifying as stewards of design collections. ([SAA](#), 2021).

4.16 Born-Digital Design Records: Practicalities from Appraisal to Use

As part of the ICAM21 online conference, this virtual session hosted in September 2021 responded to feedback and expanded upon discussions from the December 2020 panel “Digital Architectural Archive Collections: Expanding Practices & Future Uses” by bringing additional voices into the conversation. In this session, perspectives from academia and museums introduced exploratory uses and pedagogical practices working with born-digital design records, as well as providing practical approaches for appraising born-digital design and related records for collecting institutions. This breadth of topics touched on the larger conversation around software heritage, and specifically that the ‘invisible infrastructure’ our digital lives are built upon should not be overlooked or taken for granted. ([ICAM](#), 2021).

4.17 Society of American Archivists’ *Trends in Archives Practice* series on Emerging Best-Practices for Born-Digital Design Records (forthcoming)

Expected in 2022 as part of the SAA’s *Trends in Archives Practice* series, this compilation of three modules addresses the technical aspects of preservation and offers practical approaches to managing born-digital design records. The authors of these three modules represent a myriad of institutions and expertise from architectural firms, universities, and cultural institutions. They focus on the historical background of born-digital design records, offer case studies for different institution types, and host a discussion on emerging best practices around acquisition, preservation, access, emulation, and workflows. These modules are aimed at archival professionals, ranging from those who are early in their career to those more experienced, and who are interested in and/or need assistance managing born-digital design records (Winn and Williams, Eds, forthcoming).

5 Case Studies

At the time of writing this report, there are no profession-wide accepted best practices specifically for acquiring, preserving, and processing born-digital design records, due both to the inherent complications of the files and because repositories use different procedures, data, and intellectual management systems. To reflect these different approaches the following case studies provide a broad range of experience and practices currently being explored or implemented in academic, cultural, and corporate repositories. Based on structured interviews conducted via video-conference software with six archival professionals representing different institution types, sizes, and resources, these case studies describe the variety of approaches for collection development, preservation, and access within an organizational setting. Each interviewee was asked about the repository's mission and collecting scope, the current and near-future staff size and skill set, existing policies and how and if they are developed, ongoing and evolving workflows, availability of resources and leadership support of the repository, and near-term anticipated processing efforts, infrastructure developments, or policy developments.

Each case study is organized by phases of archival work grouped as follows: 'Appraisal and Acquisition', 'Arrangement and Description', 'Digital Preservation and Storage', and 'Access'. They also include an overview of the institutions, a summary table of key activities in each phase, and an analysis of the challenges and successes of their approaches. The majority of the repositories represented are US-based.

5.1 Cultural Institutions Case Study

Cultural institutions and museums collect, preserve, display, and interpret materials for research, exhibitions, and education purposes. Achieving this involves collaboration and effective communication amongst multiple perspectives and stakeholders. While this case study represents the perspectives of digital archivists, the full lifecycle of the collections is impacted by curators, archivists, librarians, collection managers, exhibit designers, communications and marketing professionals, as well as visitor engagement and experience professionals. Although not all roles are directly involved in the stewardship of collections, especially for born-digital design files, each plays a part in clarifying the opportunities and long-term significance of collecting, preserving, and providing access to researchers and exhibit visitors.

5.1.1 Institutional Profiles

Two archivists from museums and cultural institutions were interviewed for this case study.

'Cultural A' is a medium-sized European institution focused on architecture and part of a regional digital preservation system consortium of cultural and heritage institutions and organizations. As one of three archivists, the digital archivist's job title and responsibilities focus on the institution's digital policies regarding online disclosure, data management, digitization procedures and born-digital archives, with special attention on born-digital design records and questions about appraisal, acquisition, processing, and providing access to collection material.

'Cultural B' is a large-sized American institution, which is focused on supporting the visual arts. Architecture makes up a large part of the institution's collecting area. The digital archivist interviewed works in a small department of archivists and is responsible for working with a variety of born-digital files.

5.1.2 Current Appraisal and Acquisition Practices

As at many institutions, digital files have slipped into the collection as CDs or floppy disks tucked into project records. **Cultural A** has been intentionally collecting born-digital records since 2007. **Cultural A** applies the same approach to the appraisal and acquisition of both physical and born-digital design records. They evaluate the collection comprehensively, rather than separating material by format. When digital archives have been identified as significant through conversation between Cultural A and the donor, then additional attention is allocated to those materials, including analysing the directory structure and walking through the files and project folders with the donor. The digital archivist acknowledged the limitation of their technical skills to automated appraisal of born-digital content, emphasizing the value of conversations with donors to find out how the project developed, identify files that document important decision-making moments, and setting realistic expectations of what the archive can support.

The transfer of files, facilitated by the archivist, to the institution often requires specialist hardware and software to connect various legacy and modern storage devices as well as a level of familiarity to navigate and troubleshoot issues that arise from these storage devices. Write-blockers are critical to ensure valid data and file transfer onto the institution's local storage (for example, network storage or external media).

When the digital archivist at **Cultural B** has the opportunity to work with donors and their tech support to appraise and acquire born-digital design files, a conversation about the files and process takes place. Some transfers take place through the institution's IT department sending files via a 'bag' (data packaged into a standardized container for transfer based on the BagIt specification) to the digital archivist, and the digital archivist conducting checksum validation before temporarily storing them on a local secured server. To determine file formats, the files are characterised using a file format identification tool. The report is then bagged separately and stored in the digital asset management and preservation solution. These files are accessible to staff, but not to the public. The digital archivist also creates a report describing the transfer, which includes dates, type of physical media or transfer method, errors, file counts, and size.

5.1.3 Current Arrangement and Description Practices

Cultural A aspires to preserve original order, and leverages description practices to provide context for complex born-digital design files. With limited staff time, **Cultural A** establishes series at the digital media carriers (for example, CDs, floppy disks, network-attached storage (NAS) devices, and so on) and creates an inventory based on the files present in those directories, as well as capturing the file tree. An example of this inventory:

- Series 1: hard disks of personal computers from the architect's office. Currently stored in one directory for each hard disk in two representations: 1x as disk image and 1x the extracted files.
- Series 2: the digital archive of the architect's office (equals one shared folder on a fileshare). Currently stored in one directory.
- Series 3: the personal digital archive of the architect (equals one shared folder on a fileshare). Currently stored in one directory.
- Series 4: series of floppy disks, CDs and so on. Each carrier has a description in Excel, to be imported into the collection management system in the future. Currently stored in one directory for each carrier in two representations: 1x as a disk image and 1x the extracted files.
- Series 5: the architect's office's website. Currently stored in one directory.

To maintain the links and dependencies of project files, **Cultural A** does not rearrange any files, instead it uses descriptions to offer an intellectual arrangement to disambiguate files within a directory structure. In anticipation of using a digital repository that creates PREMIS-object level metadata, **Cultural A** stores the complete original file path to support future efforts to reconnect broken links to xref files. Due to competing priorities at **Cultural B**, description for born-digital design records does not usually take place beyond a collection level summary. The delay in more specific description, even when processing digital files, is due to the challenges of providing contextual description of the intent and use of born-digital design files efficiently at scale. When this description is created, it is integrated into the finding aid for the related physical materials.

5.1.4 Current Digital Preservation and Storage Practices

Cultural A is currently in the process of selecting a digital repository system as part of a multi-institution consortium, and as an interim step focuses on ‘chang[ing] as little as possible in the archives and keep[ing] all options open’. They are assessing the features and workflow practices of different digital repositories, prioritizing options that maintain folder structure and allow for local customization. The ability to customize makes open-source options most appealing to **Cultural A**, as this allows for future development of new functions in a collaborative way, such as preservation workflows for born-digital design file types that are not typically supported or explicitly addressed by digital repositories. Pointing to Tessa Walsh and Artefactual Systems’ work on the CCA’s *SCOPE: A Digital Archives Access Interface* (CCA, 2021) as inspiration, the archivist at **Cultural A** has begun developing their own programming skills to be better equipped to troubleshoot or compose workflows to improve control over born-digital design files beyond access, including pre-ingest and conducting automated processes.

Cultural A preserves the files at the bit-level. Other preservation policies for born-digital design files are still under development, including research into exchange file formats to migrate proprietary file formats. However, normalization of born-digital design files is not yet implemented. Similarly, **Cultural B** also preserves files at the bit-level during appraisal and acquisition; this is the highest level of preservation offered at the institution.

5.1.5 Current Access Practices

Cultural A’s access practices are still being developed. However, their goal is to create read-only access to born-digital design files via a PC in their reading room. Researchers would first explore the file tree with an automated inventory and then request Archival Information Package (AIP) in the reading room. Donor concerns about intellectual property issues and the reuse of their design files require stringent guidelines and restrictions to copying and dissemination to ensure that files cannot be altered or repurposed.

In the past, **Cultural A** has used online collaborative applications to provide access to digital archives for undergraduate students under the conditions of a fair use agreement that states files can be used only within the context of the class. Another possibility is for **Cultural A** to give access to born-digital design files through a virtual reading room environment, as they currently do for digitized images in their collection. However, at the time of interview, there had not yet been a request for this type of approach.

Future access considerations for **Cultural A** are dependent on the selection of a suitable digital repository system. As part of this work, **Cultural A** has gathered input from a wide range of potential users including lawyers, design researchers, architects, facility managers, and exhibition designers. All stakeholders were asked how they would use a digital file or digital archive; most users focused on an aggregated set of digital design files (such as an architect’s entire project folder), rather than a

single particular digital document. So far, the actual look and feel of the original file has not been a priority. While this is initially reassuring, and will certainly influence the development of **Cultural A's** access plans, the archivist acknowledged that with such a wide range of potential users it is imperative to keep all the options open, and that the possibility of emulating the original software experience is likely the best way to support all uses.

Once described, **Cultural B** provides access to born-digital archives on their website, as well as in their finding aids. Access to some of their digitized materials can also be found as digital objects (access derivatives) in the finding aid. If **Cultural B** receives a request for digital material that has not yet been described, the archivist gives basic access. Design files such as .DWG and .DRF file formats are made into a .PDF and offered to researchers on a computer in the reading room with read-only access. The archivist recognizes that this approach to access is not ideal but must follow the institution's procedures due to limited-term staff working on the born-digital design files. In the future **Cultural B** hopes to develop an active working relationship with one firm in particular to support a more comprehensive approach to the description and preservation of born-digital design files.

5.1.6 Analysis

	Cultural A	Cultural B
Successes	<ul style="list-style-type: none"> • Good relationships with donors, working as partners throughout the appraisal process. • Sets priorities on a collection basis, affording flexibility and opportunity to test a variety of preservation and access levels. • Plans for future possibilities, accounting for storage space for multiple copies of an entire archive, and potential for richer metadata capture. • Cooperative investment in resources lightens financial and infrastructural burden on a single institution. 	<ul style="list-style-type: none"> • Support and relationship building with donors and their IT department. • Recognizes limitations with access and offer alternatives that are aligned with institution's policies. • Digitized files are available in the digital repository and finding aid.
Challenges	<ul style="list-style-type: none"> • Navigating competing priorities in a multi institution consortium. • Lack of support and staff regarding born-digital design files. • Local customization requires additional staff time and skill development, with potential 	<ul style="list-style-type: none"> • Description of digital design files is not a priority, and they are aware of the potential issues with a decrease in demand and lack of use. • Lack of support and staff regarding born-digital design files.

	<p>risk to long-term sustainability of the digital preservation program if diverging from the original roadmap of the software.</p> <ul style="list-style-type: none"> • Customizing processing priorities on a collection basis will likely result in varying practices that require additional documentation. 	
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5.2 Academic Case Study

The collecting scope for most public and private academic repositories focuses on the rich, research-valued special collections, and the institutional records produced by faculty, students, staff, and alumni. While some repositories purchase collections, most rely on the donation of historical materials and the transfer or deposit of records by departments or units on a university’s campus. A high percentage of the historical collections that are donated are from university alumni, as well as from firms and designers not affiliated with the academic institution but are of notable contribution to the design field. Users of born-digital design repositories range from local to international researchers to students working on projects. In the last ten years, repositories have seen an increase in the acquisition and preservation of design collections, mainly of physical collections. However, interest in born-digital design records and knowledge-building among archival professionals are increasing largely due to institutional support and tools being made available to the profession.

5.2.1 Institutional (Academic) Profile

For this case study, two digital design archivists from American academic archives were interviewed. ‘**Academic A**’ is in a private institution with multi special collections departments. The archivist works in a department with over 20 staff members and has sole responsibility for processing all design records formats. The archivist receives support and guidance from the multi special collection departments’ IT staff, as well as from different departments and working groups focused on born-digital files.

‘**Academic B**’ is an archive at a public university with a small staff. Several of the staff are permanent; however, most processing is supported by grants. Unlike **Academic A**, **Academic B** receives minimal support from the institution’s IT department. The collecting scope of **Academic B** is focused on design records of hybrid (physical and born-digital) collections.

5.2.2 Current Appraisal and Acquisition Practices

At **Academic A**, during appraisal and acquisition a site visit is conducted by the archivist and IT personnel. A donor survey and box-level inventory are completed by the donor, which determine such factors as the scope and condition of the collection. The inventory also records if any external storage carriers are in the collection. The archivist at **Academic A** notes that IT’s interaction with the donor has been very helpful, as they may have more knowledge about the file structure, file transfer

needs, and legacy media. To date, there have been no direct network transfers of files, but these capabilities are available.

Like Academic A, the staff at **Academic B** request to meet with donors of the project files prior to acquisition of the collection. Both physical and born-digital files are evaluated and discussed. The logistics of transferring the files are discussed during the meeting, and the archivist receives the physical records and digital media directly from the donor. At the time of this interview, the most commonly received files were created in Adobe Suite and Microsoft Office software, as well as image file formats such as Joint Photographic Experts Group (JPEG) and Tagged Image File Format (TIFF), but not proprietary design formats.

5.2.3 Current Arrangement and Description Practices

Academic A typically receives hybrid collections of design records. Digital media is separated, and each piece given a unique identifier which is documented in a spreadsheet or inventory. A support team receives the digital media along with the inventory, and captures the contents of each piece by creating a disk image (or on rare occasions by copying the files). They then package the disk images for ingest into their digital preservation software. During this process, the team scans the disk images for viruses, after which the IT department moves them to a shared storage folder for processing. The archivist is then able to view the files of the disk image on a PC with such tools as a digital forensic software, graphic image viewer (for example QuickView+), and their digital preservation software. As processing continues, the collection-level record in their archival management system is updated with descriptive information following a combination of DACS (Describing Archives: A Content Standard) standards and the repository's own descriptive guidelines. The DIP is then linked to the digital object record attached to the finding aid, and the SIP is finally ingested into their digital preservation software.

During arrangement and description, **Academic B** adheres to MPLP (more product, less process) processing ideology. First, a spreadsheet containing a project-level inventory is manually created for each collection. Then, each piece of digital media is recorded on the spreadsheet, along with the make and model and any additional information recorded on its surface. After the inventory process has been completed, logical files are copied from the digital media, and a review of the contents is conducted to identify and extract duplicates or sensitive files. After triage, two directories are created, one containing the logical files and the other housing the associated metadata. After a final review, an AIP is created and stored on an external hard drive with a copy on a local server for future access. Throughout processing, the inventory spreadsheet is kept up to date so it can be later used as a project index alongside the finding aid. The institution recognizes that not all researchers are familiar or comfortable working with digital collections, so the project index is made available in a user-friendly PDF format. As a final step, a finding aid is generated.

5.2.4 Current Digital Preservation and Storage Practices

The archivist at **Academic A** uses their digital preservation software's services for preservation and storage of SIPs and DIPs. AIPs are transferred to the preservation department for long-term management and care, and the archivist's work is complete. According to the preservation department's website, their preservation policy focuses on preserving content and providing services established by the multi repositories that make up the institution's special collections.

Academic A is also heavily committed to maintaining and preserving obsolete software and operating systems for use and access to the born-digital design files.

For Academic B, the AIP is stored both on the institution’s server and within a multi institution consortium’s cloud-based infrastructure. The DIP is housed on an external network server, which is typically used by the repository’s reference archivist.

5.2.5 Current Access Practices

Researchers at **Academic A** must visit the archives reading room to view the physical collection, while born-digital and digitized design files can be accessed via the digital repository PUI (public user interface) accessible from their website. Finding aids are created in their archival management system and available online.

Like Academic A, **Academic B’s** physical collections are made available in the reading room. Digital collections are not yet available; however, **Academic B** intends to provide access to files from a PC (also in the reading room) that supports read-only access and has no external connections, including no internet or external media ports. QuickView+ will be used to view the files. Researchers can also access the finding aids on Academic B’s website, along with the project index (inventory).

5.2.6 Analysis

	Academic A	Academic B
Successes	<ul style="list-style-type: none"> • Communication and information sharing with donor prior to acquisition. • Relationship and support from IT and other services/teams within multi repositories. • Large staff to support all phases of lifecycle of files without overloading the design records archivist. 	<ul style="list-style-type: none"> • Communication and information sharing with donor prior to acquisition. • Multiple access points of files for researchers.
Challenges	<ul style="list-style-type: none"> • Competing priorities from multi repositories all requesting attention from the many services/teams has the potential to impede processing. • Thorough documentation and clear communication are necessary to ensure design records archivist has all information necessary to provide service. 	<ul style="list-style-type: none"> • Reliance on grant funding can cause long-term planning issues/problems. • Recognition that access is a current weakness and needs to be addressed.

5.3 Design Firm Case Study

A corporate archive's mission does not necessarily align with that of a traditional academic or cultural institution archive, most notably diverging in the communities they serve. While there has been an increase in archivists on the staff within architecture, design, and engineering firms in the past ten years, it is still a relative rarity. The scope or intention of a firm's archive can depend on a myriad of factors including:

- Age of firm.
- Intention to donate to a collecting institution.
- Exhibiting works in museum or other settings.
- Commitments through continuous work for long-term clients.
- Investment in research and development, such as construction methods or building performance.

The archive supports the firm's activities, meaning it can facilitate knowledge transfer or serve as the foundation of a firm's knowledge management program to distribute institutional memory beyond the original project team. As a result of this wide-ranging potential scope, the firm archivist, typically a position held by a single individual, often works within or closely with the business development, marketing, or communication departments. Additional collaboration with the IT department is necessary to facilitate digital preservation efforts and to remain aware of the software ecosystem the firm is using.

In addition to collaborating with departments within the firm that have their own missions and goals, the corporate archivist must continuously advocate and raise awareness around the importance of preservation and access to completed project work, as well as identify opportunities to future-proof the work of the firm for easier or more effective long-term preservation and access. This dual focus is further compounded as the corporate archivist works not only with the born-digital material but also often maintains the physical archive of paper-based records and physical models. With a broad spectrum of competing priorities and responsibilities, corporate archivists often rely on (mostly paid) interns to support their work.

5.3.1 Firm Profile

Two American firm archivists were interviewed for this case study. **'Firm A'** is a mid-sized multi-office practice with an international project scope. There is one archivist to steward the nearly 50 years of project work, with support from the project teams, marketing and business development department, and IT department.

Established around 25 years ago, **'Firm B'** is also a mid-sized multi-office practice with several types of project, but whose work is mostly American and European in scope. There is one archivist in the firm, who is positively supported by the IT department and the special projects/exhibitions department.

5.3.2 Current Appraisal and Acquisition Practices

Due to the iterative nature of design work and occasionally precarious nature of funding for built projects, a corporate archive within a design firm does not have as distinct phases as a traditional collecting repository does. The firm archivist's responsibilities often encompass 'inactive' files and the stewardship of project records both for fulfilment of legal functions and records retention schedules, and for preservation and the provision of access to files in the same state as they were created. Each firm has its own software ecosystem, though common programs and associated file types include:

- Adobe Suite (for example .INDD, .PDF, .JPG).
- Microsoft Office (for example .DOC, .XLSX).
- AutoDesk applications (for example .RVT, .DWG).
- ESRI ArcGIS and GoogleEarth (for example .DBF, .SHP).
- SketchUp (for example .SKP).
- Rhinoceros 3D (for example .3DM .3DS).
- Grasshopper (for example .GH).

For **Firm A**, part of the project team's workflow includes saving specific deliverables or useful images to be used for press releases and publication work. The timing of creating these reference files can be challenging, as the design team often takes a break after completing a milestone. Design team interns frequently facilitate this process by pulling together the initial documents that are reviewed and approved as accurate representations by the project team. These files are saved outside the active project folder, establishing a clear delineation of purpose, and continue to be built upon throughout the life of the project. This provides a fairly comprehensive cache of referenceable materials that are saved to a universally accessible space on the server.

Additionally, **Firm A** is committed to consistently documenting all contributors to a project, providing valuable institutional knowledge and recognition of the project team. This contextual information is formally captured in a labour report created from the firm's accounting software that documents all employees that billed hours to the project. This report is then used to create project team credits, which are extracted from the project during the 'post-production' process. This is when select drawings, images, project narratives, and project information are lifted from the project to become 'media' assets for use by the marketing teams and as a reference for staff. The files are kept in a media repository accessible to all staff (whereas the archived project material is limited access).

Also a lone practitioner, the archivist at **Firm B** recognizes that time allocation and effort distribution are challenges. One of their main focuses is advocacy, which is a struggle at times due to a demand-driven environment and tight deadlines. As a first step, the archivist works with the project team to ensure all born-digital files created for a project are saved to their respective project folder and transferred with all other project records (such as physical models and paper-based documents) to the archives as part of the project close-out workflow. At the time of this interview, the preservation of born-digital design files in particular was not given any additional or special treatment. Similar to Firm A, **Firm B** places an emphasis on capturing milestone deliverables at the end of each project phase, rather than undertaking any archival processing of the actual project files. At the end of the design phase, project leaders prepare the files according to a checklist created by the archivist, and the project lead uploads them to the DAMS to be utilized by the design teams to reference past project work. The work of the project leader is key in the appraisal process, as they upload the project files to the vendor-supported cloud storage. Due to the complex nature of multi-firm design and consultant teams on architectural projects, shared custody of the files can be a challenge for acquisition. No solutions were offered, but the authors believe recognizing this issue is important, and that ownership of records should be addressed in future contracts.

5.3.3 Current Arrangement and Description Practices

The project folder structure and file-naming conventions are the core elements of arrangement and description of project files within a firm, as well as those donated to institutions. **Firm A** uses a folder template that is prepopulated with subfolders. This is a proactive and critical preventative measure to avoid ambiguity or confusion within a project folder caused by individuals applying their own idiosyncratic organizational practices to the files. **Firm A** has attempted to retain as much consistency as possible in its project folder structure, while remaining flexible to accommodate

changes in practice over time, such as the recent increase in cloud-based Software-as-a-Service (SaaS) that requires project folders to be synced to active cloud-based files or saving backup copies to the project folder. This has been successful due to the buy-in of the design teams, who understand the long-term benefit of complying with the organizational infrastructure. Additionally, **Firm A** stores a script-generated text file (using directory list command in the Windows terminal: 'dir /b /s > 'filepath'.txt) of the directory and file list with the 'archived' project files. While this is currently only created when the project folders have been 'split' or reorganized, as the firm's close out/archive transfer process continues to mature and more resources become available, the goal is to make this a uniform action for all project records. **Firm A** also consistently collects information about each project as part of the project closeout process, including: who worked on the project, how many hours were dedicated to it, who took the photos and what the licence is for the photos, as well as project information such as client, size (for example, site, gross and net square footage), location, consulting team, specs, performance, lessons learned, post-produced drawings/narratives, etc.

Firm B's archivist has cultivated a good working relationship with their colleague within the IT department due to hours of advocacy work in meetings and conversations. This relationship is extremely important as much assistance is needed from IT. Project leaders at **Firm B** are responsible for implementing the firm's established folder structure. However, the project team's dissatisfaction with the folder structure results in frequent modifications or additions to better suit their preferences for record filing and management. Most standard digital preservation workflows, beyond typical IT-managed disaster preparedness like regular fixity checks, have not been established at this time due to staffing and resource challenges.

5.3.4 Current Digital Preservation and Storage Practices

When a project is completed at **Firm A** (often a challenging status to confirm due to added services, ongoing conversations, or finalizing billing), the firm's IT staff runs a custom script to transfer the project folder from the active project drive to the limited-access archive drive. The IT infrastructure of **Firm A** includes a mirrored location of on-premises servers, frequent backups of the regularly changed active project folder drive, and less frequent backups for the drive hosting the project reference files, as well as the archive server. At the time of this interview, metadata for individual files or directories was not a central aspect of **Firm A's** current preservation activities, due to lack of resources and priorities. Should they adopt metadata capture in the future, it would likely be for ensuring file fixity, or potentially for academic interest in types of files created throughout the course of the project.

Firm B's storage workflow is divided between active and inactive project files. The former is dependent on the project leader saving files appropriately within a project's folder structure on a vendor-supported cloud server. Once the project is inactive (defined by the firm as no activity within the project folder for over one year), the complete project folders are moved with the support of IT to a local file server on the archive drive. Copies of key project deliverables, including digital images and PDFs of documents, are stored in the firm's DAMS.

5.3.5 Current Access Practices

When project files on the archive drive are needed, **Firm A** provides access by making a copy and temporarily saving the files to a reference folder that is deleted after that need has passed. This ensures integrity of the original project files, while allowing the requester access to the full functionality of the files. **Firm A's** current server system set up allows for virtual private network (VPN) access, as well as for remote work.

All staff at **Firm B** can access files on the archive drive with read-only privileges. A limited number of individuals with administrative rights can make changes to files on this network drive.

External access requests are made at times by university students interested in learning and studying techniques and projects produced by **Firm B**. Packages of files (.PDFs and .JPEGs only) are shared via a cloud-based secured link to the students.

5.3.6 Analysis

	Firm A	Firm B
Successes	<ul style="list-style-type: none"> Well-established folder structure and file-naming conventions upheld by project teams. Strong version control and project documentation to ensure long-term findability of project files. Super-user community within the firm understands and supports the distinction between project folder and reference materials created at project milestones. No known instances of significant data or file loss, indicating preservation practices seem to be meeting the needs of the firm. Good working relationship with the IT department. Consistently capturing core data elements about each project as part of the archival process and project close out, including specifics about project team, project details, and lessons learned. 	<ul style="list-style-type: none"> Good working relationship with IT department. 'Checklist' for the digital files created by archival professional. Cloud server storage supported by vendor that meets the needs of firm. Preservation practices seem to be meeting needs of the firm. Read-only self-service to archived project files for all staff meets the needs of the firm.
Challenges	<ul style="list-style-type: none"> Current infrastructure does not support additional preservation efforts. Limited staff availability and multiple priorities restrict opportunity for undertaking digital preservation practices. Business case required for making additional investments to the archival infrastructure, including automated metadata capture. 	<ul style="list-style-type: none"> No support of 3D files. Archivist must rely on design team and IT to acquire and preserve. Shared custody of joint project files. Limited support for digital preservation practices at the firm. Additional staff required to implement digital preservation practices.

6 Case Study Conclusions

The case study interviewees had varying levels of understanding of the design process behind the creation of records; how researchers intend or expect to use specific files or collections; and principles and workflows of digital preservation. Appreciating that archival professionals working with born-digital design records are stretched to become expert in the nuances of the design process, born-digital design files, and digital preservation practices, makes the need for collaboration and open dialogues critical. Archival professionals must leverage collective knowledge and engage in collegial conversations to explore and establish practical approaches, while acknowledging the unique parameters or conditions at each institution. For example, some repositories have already made their workflows and documentation available to the public, specifying what programs and infrastructure they have developed (for example, the CCA's documentation Digital Archives Processing Manual, available online on GitHub ([CCA, 2021](#))).

Some of the notable takeaways from the case studies include the acknowledgement of the changing environment of design practices and outputs, and the need for repositories to be proactive and flexible in their approach to acquisitions, preservation, and access, regardless of the organizational type and/or phase of the lifecycle of born-digital digital files. In addition, the case studies provide several steps that archival professionals can take to help manage the acquisition, preservation of, and access to, the files:

- **Establish a relationship with each donor.** As seen in the Cultural and Academic case studies, an ongoing relationship or conversations with the donor proved extremely helpful in understanding the content of the files and software dependencies. A repository should engage the donor in conversations about their files and folder structure to better understand the access and preservation needs of the donor-created files. It is very common for institutions to receive hybrid collections, with the digital files transferred via CDs, external hard drives, and flash drives and predominantly created in Microsoft Office, Adobe Suite, and AutoDesk applications (such as Word, Excel, InDesign, Illustrator, AutoCAD, Revit, Maya, and so on), as well as ESRI ArcGIS. The authors recommend conducting a survey or interview with the donor, preferably with a checklist or questionnaire to consistently capture information for each collection (Winn and Williams, Eds., forthcoming).
- **Know your users' needs.** Each of the repositories acknowledged their designated community and determined the most practical, efficient method of delivery for their users, whether it be in a reading room, file management system, and/or transfer method.
- **Support from IT and/or vendors.** Establishing support from the repository's IT department to aid in the acquisition, preservation and access of born-digital design files was invaluable, especially for the Firms' case studies. Through such collaborations, core functions of digital preservation can be shared; however, archival professionals still need to remain abreast of digital preservation best practices.
- **Senior manager/stakeholder support.** Support and endorsement from the senior managers and stakeholders are important for any repository, which was particularly clear in the Firms' case studies.

The authors of this report recommend that a repository's mission or collecting mandate should be supported by the policies and procedures that outline or guide the work of collecting, processing, and providing access to collections. However, factors such as financial constraints, lack of administrative support, limited readily available archival skill sets, and other competing priorities may affect a repository's ability to create well-informed policies. The exercise of creating them can help identify some of these limitations:

- Collecting policies establish the scope of what a repository does or does not collect, including the types, format, or size of material. Having these activities clearly defined helps to communicate the roles and responsibilities of a repository, and aids in meeting the needs of researchers. Leveraging Recommended Formats Statements and developing collecting policies provides repositories with a baseline for defining the institutional resources needed and beginning conversations with potential donors. For example, UK Data Services, the Library of Congress, and the US National Archives and Records Administration all have published statements.
- Appraisal and acquisition policies provide guidance for archival professionals and their organizations when establishing a relationship with the donor, and facilitate conversations that make explicit the designer's tacit knowledge of their personal and/or firm's practice. Such information includes context about the project's history, the design process, file formats present in the donation, as well as details about software use, both for a specific project or within a firm more generally. The outcome of these conversations can offer valuable insights supporting the repository's efforts to preserve the files and give long-term access to their researchers.
- Preservation policies define and guide the long-term management of records, including the tier or level of intensity ([Arroyo-Ramírez et al., 2020](#)), for both physical and digital. For digital material specifically, policies may delineate preferred and accepted file formats, as well as document organizational decision-making about record transfers, asset management systems, access, number of copies kept and made, preservation monitoring, and other activities related to the care and maintenance of born-digital design records. Having these activities clearly defined helps to communicate what resources are needed in the near term, and what to address through future investments in staff and infrastructure development.

Anecdotal evidence from conversations with designers and archival professionals over the last 30 years supports the assertion that the variation in each designer's and firm's design practice has resulted in a wide range of born-digital design file types associated with each phase of design. Understandably, this can be overwhelming for archival professionals unfamiliar with the design terminologies, workflows and file types. In the last two years, the archival profession has hosted more candid and practical-oriented conversations to support colleagues in the appraisal process. For instance, a forthcoming article in SAA's journal, *American Archivist*, will feature an appraisal tool for several organizational types that collect design records ([Leventhal, Thompson, Anderson, Schubert and Altenbach, 2021](#)). The appraisal tool, which operates as a grid articulating phases of design and key categories of records relevant to the institution type (and also includes a glossary of those terms), aims to assist archivists in better understanding the files generated by the architects and design professionals. These various policies should be revisited regularly to ensure they appropriately reflect a repository's collecting scope, and reaffirm or adjust the best preservation and access practices possible.

7 Current Activities and Research

7.1 Current Research

The challenges of preserving design process documentation are long standing, even before born-digital design technologies were incorporated into the disciplines. Four overarching issues come to mind:

1. The time-pressured nature of design and construction work affords little time to preservation considerations.
2. The lack of an inherent business case for taking additional steps to thoughtfully save project files ([Library of Congress](#), 2018, Greg Schleusner).
3. The predominant perspective of design professionals that the built structure or space is the document of value to save and study.
4. The overwhelmingly wide range of available design software and file types generated.

Although design and construction professionals have become more aware of the fragility and precarious nature of their born-digital design records for long-term access, the urgency to address the root issues is not felt as acutely across creator communities as it is within the archival community. This can be attributed to a level of comfort within this super-user community to troubleshoot file dependency issues, or acceptance of loss of files and the need to recreate drawings or models as needed.

Without an immediate business need for these professional communities to save documentation of their design processes, beyond legal considerations of records retention, this documentation will continue to be at risk. An example of this is with the management of facilities, and in particular nuclear facilities. These collections comprise active records, referred to throughout the life of a structure and include making repairs, renovations, and, in the case of nuclear decommissioning sites, tracking the previous activities and material stored in certain locations for structural and environmental concerns. For instance, Sellafield Ltd., the Site Management Company for Europe's largest nuclear site, has record holdings of almost 3,000,000 files in its document management system, and creates new records at a rate of close to 3,000 documents a month. These records document each major issue or milestone drawing sets as structures are constructed, renovated, or demolished on the site, and are considered the final copy. Additionally, this type of organization is governed by legal considerations that are often articulated by records management schedules and subjected to more stringent reviews than an institution collecting design records for future research.

This report does not argue for the priorities of design and construction professionals to change, but rather to explicitly acknowledge these obstacles and consider successful approaches to managing expectations for acquisition, preservation, description, and access of design and construction records. It is also recognized that these changes will have to come with significant cost or time savings in order to be considered compelling for design and construction professionals.

With limited resources of staff, space, and funding, archival professionals are continuously asking questions about collecting priorities with a long-term view to what can be sustainably preserved, described, and accessed. The first FACADE project in 2006 attempted to address this question with a comprehensive overview of a project's records, creating a PIM. However, the realities of varying practices between design firms, or even between projects within the same firm, including selection of software and how it is used, present additional obstacles that require more clarification. To address this tacit knowledge about unique or varying design practices, collecting institutions, and even some firms, have begun proactively interviewing designers to document intent as well as to highlight features of a project or the project files. The value of interviews with record creators has

been resounding, from the interviews with contributors to the CCA's *Archaeology of the Digital* (CCA, 2013); to Balmori Associates' description of incorporating creating project narratives at the conclusion of a project (Library of Congress, 2018, Noemie Lafaurie-Debany); and to Wim Lowet's December 2020 presentation *Building Archival Strategies Together: How Appraisal Sessions can Help to Establish a Management Plan for Digital Design Archives* (Library of Congress, 2020). All these efforts demonstrate that there is still much unknown to the archival community about born-digital design record creation and potential future use. Archival professionals are encouraged to continue exploring the topic in a variety of outlets, including embracing failure as a learning opportunity and articulating lessons learned for the collective benefit.

Successful and invaluable efforts aimed at a collective benefit include the Library of Congress's annually updated Recommended Formats Statement (Library of Congress, 2021); the US National Archives and Record Administration's Records Management Regulations, Policy, and Guidance's 'Appendix A: Tables of File Formats' (National Archives and Record Administration, 2020), ongoing contributions to PRONOM, and research on specific software such as the Sketchup file format and software analysis completed in 2019 by the Flanders Architecture Institute. Looking beyond the specific resources for born-digital design records, resources such as the Ohio College Library Center's (OCLC) 2021 report 'Total Cost of Stewardship: Responsible Collection Building in Archives and Special Collections' (Weber et al., 2021) addressed critical issues such as the long-term financial investment for stewarding born-digital design records can be better understood.

Along the lines of the OCLC report on the total costs of collection stewardship, the challenge of answering the question 'what to save?' from the born-digital records that represent iterative, non-linear, and multi-faceted projects is not unique to the records of design and construction disciplines. Eric Kaltman's exploration of video game production processes and records highlights several shared obstacles to collecting and understanding born-digital design records. Noting that it is 'a circular problem of not knowing enough about the processes to articulate, in practical detail, what aspect of [the records] are most important to save' and that these records 'represent a set of under analysed digital infrastructures and design ecologies' (Kaltman, 2020), Kaltman identifies multiple disciplines, from science and technology studies to computer science and archival science, whose theories and methodologies could be applied in approaching the multidisciplinary effort of video game production. In 'An Experimental Archaeology of CAD: Using Software Reconstruction to Explore the Past and Future of Computer-Aided Design' Daniel Cardoso Llach and Scott Donaldson similarly highlight a myriad of potential future areas of study using born-digital design records as they become available (Llach and Donaldson, 2019). This spectrum of users ranged from historical research, architectural and design disciplines, to media, science, and technology studies.

As outlined in Section 4 **Key Initiatives**, there has been an ongoing debate within the archival community for the past 25 to 30 years about the collecting scope of born-digital design files and their software. Throughout the 2010s, this debate expanded to an evaluation of the veracity and effectiveness of free readers, exploring the potential of emulation, and weighing the costs and benefits of collecting and supporting original software. Other than Tessa Walsh's 2016 CCA Access to Born-Digital Archives User Survey (Walsh, 2017) there have not been many instances documented yet of researchers requesting or requiring to see design files in their native environment (including in those institutions in this report's case studies). However, Llach and Donaldson's article offers a compelling argument for how the native environment supports enrichment of understanding from 'technological and design histories, [to] outlining the origins of contemporary architectural languages and subjects, as well as engaging with present-day technological frameworks' (Llach and Donaldson, 2019). Furthermore, cross-disciplinary collaborations, such as the Fall 2019 Carnegie Mellon course 'Special Topics in Computational Design: Experimental Archaeology of CAD' (Llach, 2019), demonstrate the additional value and potential insights when researchers have access to the 'visual, functional, and interactive aspects of software' (Llach, Kaltman, Erdolu, and Furst, 2021).

In preparation for the anticipated shift in expectations and experiences of researchers working with hybrid and entirely born-digital design collections, the born-digital design archival community has made a concerted effort over the past decade, building a semi-formal community of practice and developing both technical and contextual resources. SAA's Digital Design Records Taskforce ([DDRTE](#), n.d.) has conducted research and provided documentation on a range of topics from accounting for digital records in Deeds of Gift ([Leventhal et al.](#), 2019) to applying the 2017 *University of California Guidelines for Born-Digital Archival Description* ([University of California Systemwide Libraries](#), 2017) to born-digital records in architectural collections ([Leventhal et al.](#), 2020). This collaborative work undertaken by archival professionals across institutions in the US has begun to expand in scope through an internationally accessible DesignArchivists Slack Workspace (designarchivists.slack.com) created in 2020 (To join, contact the authors of this report). Individual institutions, such as the CCA, have made substantial contributions to the archival community's capacity to ingest and process born-digital design records by making their resources publicly available on GitHub ([CCA](#), n.d.a). The Flanders Architecture Institute has also made a valuable contribution, publishing a thorough investigation of the features and evolution of SketchUp ([Vanstappen](#), 2019). As more institutions collect born-digital design collections, the opportunity should not be wasted to develop a collaborative learning community of design, historian, archival, and museum professionals.

7.2 Current Tools and Practices in Active Design Firms

As introduced by Tessa Walsh at the 2017 Architecture, Design and Engineering Summit ([Library of Congress](#), 2018), there are two parts to the current conversation around born-digital design records that need to be taking place among all stewarding or collecting institutions, not just firm archivists. 'The first is addressing the backlog of unpredictable digital files and obsolete software that have and are slowly making their way into private or institutional archives; and the second is developing a future world of platform independent file types and archival standards-based record guidelines' ([Leventhal](#), 2018, p. 6). While neither is an especially easy undertaking, the latter presents additional obstacles as the design software market continues to grow and adapt, and as designers continue to explore this ever-burgeoning software ecosystem. While the majority of this report has been focused on the potential backlog and accounting for the rich ecosystem of born-digital design records, this section offers a look ahead to current trends in design software development and design practitioner interests, behaviours, and concerns.

Over the past decade, as cloud computing has continued to mature and new business models have developed for software vendors, SaaS and cloud-based programs are becoming the norm for design firms. The COVID-19 pandemic, and the need to support remote work, have reinforced this shift and solidified practices that will likely persist after the public health needs for social distancing subside. Based on conversations with a generative design software developer, practising architects, and virtual reality specialists at medium- and large-sized American-based firms with international practices, both the technical infrastructure and design workflows of current design firms have made remote and nimble collaboration the priority.

By sharing cloud-based models using software such as Revit360 and other cloud-based products, designers have continued longstanding traditions of the design process such as group brainstorming, sketch sessions, and physical pin-up walls. The need for real-time communication via dynamic messaging platforms like Slack or creating collaborative working spaces in the form of virtual pin-up spaces or virtual sketch sessions through video conference calls have become normalized. Collaboration tools such as Miro ([Miro](#), 2019) provide project teams with unlimited space to share unstructured data, and support export options such as JPGs or PDFs in vector quality preventing pixelation regardless of the image size. The desire for simultaneous authorship and collaborative drawing is also supported, using video conferencing tools that offer an annotation feature allowing a

project team to look at the same base drawing and apply rough annotation and sketches in a similar way to using tracing paper over a printed plan or topographic base drawing. Since this requires computer proficiency and specialized setup to draw with the precision desired, practitioners are motivated to hone this skill and become more effective at communicating in a digital space. Virtual Reality (VR) and Augmented Reality (AR) are other visual communication methods with platforms such as Arkio ([Arkio](#), n.d.) that enable design teams to sketch and review designs in a more immersive experience through headsets or mobile devices, rather than export to 3D design software. In addition to seeking new methods of remote collaboration, workflows and reliance on established tools like Bluebeam Revu, a document and project management tool predominantly used to review and provide annotation on drawings, are becoming more formalized.

Design software development is focused not only on collaboration, but on providing more integrated and holistic environments to host as much information in one place as possible. Major design software vendors such as Autodesk, Microstation and Trimble all offer platforms to support either a hub-and-spoke business model that connects disparate data or files created in multiple software, or a one-stop-shop model hosting much of the project lifecycle's documentation. Additionally, more specialized software, such as generative design program Hypar ([Hypar](#), n.d.) are intentionally developing and explicitly highlighting their integration capabilities with the more mainstream and holistic programs like Autodesk's Revit and Robert McNeel & Associates Rhinoceros 3D (colloquially referred to as Rhino; [Robert McNeel & Associates](#), 2019). As part of this integration and compatibility push within the software industry, vendors are also promoting the standards and other open and reusable formats they support like IFC (Industry Foundation Classes, a platform-neutral and open-file format specification that is not controlled by a single vendor or group of vendors), JSON (JavaScript Object Notation, a lightweight data-interchange format), and glTF (a standard file format for three-dimensional scenes and models).

While these cloud-based software platforms and tools offer efficiencies for current and future design and construction work, they present additional collection, preservation, and access issues for the archival community. Cloud-based software adds layers of complexity to the existing challenges identified with locally hosted software discussed throughout this report, including proprietary formats and complex relationships between files. These additional issues include: records management (for example, remembering to save record sets to the firm's/client's server), versioning and scope of responsibility (such as tracking the edits and managing access levels between collaborating firms), and external infrastructure components (such as unaccounted for or undocumented changes to cloud-based software). The rate at which these products are released, as well as adopted by larger firms, is another complicating factor and merits additional exploration and discussion within the archival community.

There are more cross-discipline discussions to be had, and several promising developments from the software vendor and design practitioner communities that should give the archival community hope and serve as opportunities for future engagement. As previously mentioned, Autodesk recently expanded access to previous versions of software to five versions back, rather than three ([Autodesk](#), 2020). The second is a renewed effort for a Universal BIM Standard in the US, announced in January 2021 ([Peters](#), 2021). These developments indicate conversations happening amongst and between design practitioners and their software vendors, presenting opportunities for the archival community to engage, raise awareness about concerns and challenges, and possibly offer guidance about best practices.

8 Summary of Key Points

With the explosion of development in design software in the 1980s and 1990s, the archival profession has taken steps to better understand the needs to acquire, preserve, and make available born-digital design files. However, there is more to be done. For instance, robust relationships between the architecture, design, and engineering, as well as archival, disciplines are needed. As many architecture, design, and engineering professionals learn about the visual and contextual elements needed to develop digital visual literacy in higher education, the transfer of some of this knowledge to the archivist will result in a better understanding of the information and the complexities in the digital files. Additionally, this may also assist the archival professionals in describing the files for access or providing reference assistance to researchers in the institution's reading room as remote access is not supported by institutions at this time.

As with the growing trend of cloud-based software programs and SaaS, archival professionals should start to develop strategies for the acquisition, preservation, and access of files within these systems, as well as the software itself. The popularity of these solutions was evident within the **Firm Case Studies** with daily operations, and the transition of many firms to remote working due to the COVID-19 pandemic. To deal with the preservation of these systems and files, conversations between the archival professionals and donors must start or continue. Communication will aid in better understanding the software and systems used, when and why software is used during a project, and how and where the critical information is stored.

Within the case studies, it was evident that the repositories represented had different methods and solutions for acquisition, preservation, and access to, their born-digital design files. For now, and likely always, there is no one-size-fits-all solution; but rather a continuing proactive effort by the archival profession to develop standards and best practices, including a practical approach to preservation based on available resources and staff skills. Support from repository administrators and stakeholders is extremely important, and will be key to effectively navigating the expensive and time-consuming work required to decipher content, appraise, and preserve born-digital design files.

The knowledge gained through relationship building and community sharing from the past 30 years has been evident in publications and symposiums on design files, such as Ball's *Preserving CAD* report (Ball, 2013) and the collaboratively hosted 2017 conference held at the Library of Congress (Leventhal, 2018) that brought together architecture, design, and engineering professionals and archivists. As a collective of stakeholders from the archival, architecture, design, and engineering professions, we must continue to share our lessons learned from hands-on experience and research through future reports, workshops, and symposiums on the advancement of the preservation of, and access to, born-digital design files. For years, the archival community has been tenuously bracing itself for the needs of future researchers relying on born-digital design files. Now that this new wave of study has arrived, it presents an opportunity for all stakeholders to articulate what can, and should, be done with born-digital design files.

9 Glossary

.3DM is an open-source file format that is used for 3D graphics software. It contains 3D models along with their dependent elements such as surface, points, and curve information ([Aspose Pty](#), n.d.a).

.3DS is a file format that represents 3D Studio (DOS) mesh file format used by Autodesk 3D Studio. It contains data for 3D representation of scenes and images and is one of the popular file formats for 3D data import and export ([Aspose Pty](#), n.d.b).

Access is assumed to mean continued, ongoing usability of a digital resource or digital record, retaining all qualities of authenticity, accuracy and functionality deemed to be essential for the purposes the digital material was created and/or acquired for ([Digital Preservation Coalition](#), 2021a).

Acquisition is the process of seeking and receiving records from any source by transfer, donation, or purchase ([SAA](#), n.d.a).

Appraisal is the process of identifying materials offered to an archive that have sufficient value to be accessioned ([SAA](#), n.d.b).

Archival Information Package (AIP) An Information Package, consisting of the Content Information and the associated Preservation Description Information (**PDI**), which is preserved within an OAIS. ([DPC](#), n.d.c)

Archive is a physical or digital collection of historical records ([SAA](#), n.d.c).

Arrangement is the process of organizing materials with respect to their provenance and original order, to protect their context and to achieve physical or intellectual control over the materials ([SAA](#), n.d.d).

Augmented Reality (AR) is an interactive experience of a real-world environment where the objects that reside in the real world are enhanced by computer-generated perceptual information, sometimes across multiple sensory modalities, including visual, auditory, haptic, somatosensory and olfactory ([Wikipedia](#), n.d.a).

Bag is a container essentially composed of three elements: a bag declaration text file, which is like a seal of authenticity; a text-file manifest listing the files in the bag; and a subdirectory (usually titled 'data') filled with the digital content. The manifest is machine-readable for automated data ingest ([Library of Congress](#), n.d.b).

BagIt a hierarchical file packaging format for storage and transfer of arbitrary digital content ([Boyko, Kunze, Littman, Madden, and Vargas](#), 2012)

Bit rot is the corruption of the lowest level of digital data ([SAA](#), n.d.e).

Born-Digital refers to digital materials which are not intended to have an analogue equivalent, either as the originating source or as a result of conversion from analogue form. This term has been used in the [Digital Preservation] *Handbook* to differentiate them from 1) digital materials which have been created as a result of converting analogue originals; and 2) digital materials, which may have originated from a digital source but have been printed to paper, such as some electronic records ([DPC](#), 2021a).

Born-Digital Design Records is an umbrella term used in this report to refer to the broad range of digital file types and records created throughout the design and construction processes.

Breaking, or hacking/cracking of software, is the modification of software to remove or disable features which are considered undesirable ([Wikipedia](#), n.d.b).

CAD, or computer-aided design, and **CADD**, computer-aided design and drafting, is technology for design and technical documentation, which replaces manual drafting with an automated process. This refers to both 2D and 3D digital representations ([Autodesk](#), 2020b).

DACS (Describing Archives: A Content Standard) was published in 2004 and made an official standard in 2005. It was the first SAA descriptive content standard to provide guidance for all levels of description in finding aids. In 2013, the second edition removed Part III, which had addressed the description of corporate bodies, persons, and families. These rules are maintained by the Society of American Archivists, specifying the data elements to be used to represent an archival resource and its components ([SAA](#), n.d.f).

Digital Asset Management System (DAMS) is a software and systems solution that provides a systematic approach to efficiently storing, organizing, managing, retrieving, and distributing an organization's digital assets. ([IBM](#), n.d.)

.DBF is a database file used by a database management system application called dBASE ([Aspose Pty](#), n.d.c).

Description often detail physical characteristics, informational content, and functional purpose. The process of describing archival resources can include analysing, organizing, and recording details about the formal elements of a record or collection of records ([SAA](#), n.d.g).

Digital media is a file storage device or carrier for digital files (for example CDs, floppy disks, flash drives, and so on) ([Wikipedia](#), n.d.c).

Digital preservation is the management and protection of digital information to ensure authenticity, integrity, reliability, and long-term accessibility ([SAA](#), n.d.h).

Dissemination Information Package (DIP) is distributed to a consumer by the repository in response to a request, and may contain content spanning multiple AIPs ([SAA](#), n.d.i).

.DOC is a well-known format for Microsoft Word documents ([Aspose Pty](#), n.d.d).

.DWG represent proprietary binary files used for containing 2D and 3D design data. They represent the binary file format for CAD drawings ([Aspose Pty](#), n.d.e).

Emulation is a means of overcoming technological obsolescence of hardware and software by developing techniques for imitating obsolete systems on future generations of computers ([Burgess](#), 2020).

Emulation infrastructure is the technical framework of hardware and software that supports access to born-digital resources originally created by obsolete systems ([Anderson](#), 2020).

Fixity check is a method for ensuring the integrity of a file and verifying it has not been altered or corrupted. During transfer, an archive may run a fixity check to ensure a transmitted file has not been altered en route. Within the archive, fixity checking is used to ensure that digital files have not

been altered or corrupted. It is most often accomplished by computing checksums such as MD5, SHA1 or SHA256 for a file and comparing them to a stored value ([DPC, 2021a](#)).

Generative design is an iterative design process involving a program that can generate multiple outputs that meet certain constraints or parameters set by the designer, who will fine tune the options and select specific outputs or change input values, ranges and distribution ([Farmakis, 2021](#)).

.GH is associated with the Grasshopper, a graphical algorithm editor tightly integrated with Rhino's 3-D modeling tools for Windows and Mac ([File Extension.org, n.d.](#)).

glTF, or Graphics Language Transmission Format, is an open 3D model and scene format designed for efficiently transmitting rich scene 3D data. It has been created and managed by the Khronos 3D standards group since 2013 ([ThreeKit, n.d.](#)).

.INDD is an InDesign Document file that's most commonly created by and used in Adobe InDesign. The file stores page content, formatting information, files, and more ([Lifewire, n.d.](#)).

Industry Foundation Classes (IFC) is a data model intended to describe architectural, building, and construction industry data ([Wikipedia, n.d.d](#)).

Institution is an umbrella term used in this report to describe repositories, organizations, academic institutions, cultural heritage institutions, companies, and any other entity that creates and keeps or collects born-digital design records.

.JPG (Joint Photographic Experts Group) is a file format used for images and is part of the Adobe Suites ([DigiCOPY, n.d.](#)).

JSON is an [open standard file format](#) and [data interchange](#) format that uses [human-readable](#) text to store and transmit data objects ([Wikipedia, n.d.e](#)).

Logical files contain a description of records found in one or more physical files. A logical file is a view or representation of one or more physical files ([IBM, n.d.](#)).

MPLP is the abbreviation for the processing model of 'More Product, Less Process' which establishes a minimal processing level for arranging and describing archival series and collections in order to reduce or avoid backlogs ([SAA, n.d.j](#)).

Open Archival Information System (OAIS) The OAIS abbreviation is also used commonly to refer to the Open Archival Information System reference model standard which defined the term. The standard is a conceptual framework describing the environment, functional components, and information objects associated with a system responsible for the long-term preservation. As a reference model, its primary purpose is to provide a common set of concepts and definitions that can assist discussion across sectors and professional groups and facilitate the specification of archives and digital preservation systems. ([DPC, n.d.c](#))

Phase(s) of design describe the standard five phases of a design project: Schematic Design, Design Development, Construction Documents, Bidding, and Construction Administration ([Valdes, n.d.](#)).

Preservation Description Information (PDI) Preservation Description Information. The information which is necessary for adequate preservation of the Content Information and which can be categorized as Provenance, Reference, Fixity, Context, and Access Rights Information (OAIS term) ([DPC, n.d.c.](#))

.PDF (Portable Document Format) is a file format developed by Adobe as a means of distributing compact, platform-dependent documents ([DigiCOPY](#), n.d.)

Project Information Model (PIM) is developed progressively, first as a design intent model then as a virtual construction model. It typically consists of a federated building information model, a range of non-graphical data and documentation. Starting off as a design intent model, the level of detail will increase and, eventually, become a virtual construction model containing all objects needing to be manufactured, constructed or installed ([McPartland](#), 2017).

QuickView+ is a graphic image viewer created by Microsoft ([Microsoft](#), n.d.).

Repository is an institution focused on the care and storage of items of continuing value, particularly records ([SAA](#), n.d.m.)

Restricted (sensitive) file contains personal or confidential information (legal, financial, or personnel) that should be protected from public scrutiny ([SAA](#), n.d.l).

.RVT is Autodesk's proprietary format for Revit files. Revit is Autodesk's building information modelling (BIM) program that is used to create 3D building designs for floor plans, elevations and sections ([Aspose Pty](#), n.d.f).

.SHP is the file extension for one of the primary file types used for representation of ESRI Shapefile. It represents geospatial information in the form of vector data to be used by Geographic Information Systems (GIS) applications ([Aspose Pty](#), n.d.g).

Submission Information Package (SIP) An Information Package that is delivered by the Producer to the **OAIS** for use in the construction or update of one or more Archival Information Packages (**AIPs**) and/or the associated Descriptive Information (OAIS term) ([DPC](#), n.d.c.)

.SKP is a file extension that is a three-dimensional model created by SketchUp software ([Openthefile](#), n.d.).

Software breaking/cracking is the modification of software to remove or disable features which are considered undesirable by the person cracking the software, especially copy protection features (including protection against the manipulation of software, serial number, hardware key, date checks and disc check) or software annoyances like nag screens and adware ([Wikipedia](#), n.d.b).

Submission Information Package (SIP) is an Information Package that is delivered to the repository and digital storage system for ingest ([International Association of Sound and Audiovisual Archives](#), n.d.).

Visual Programming Scripting/Language (VPL) is any programming language that lets users create programs by manipulating program elements graphically rather than by specifying them textually ([Wikipedia](#), n.d.f).

Virtual Reality (VR) is the computer-generated simulation of a three-dimensional image or environment that can be interacted with in a seemingly real or physical way by a person using special electronic equipment, such as a helmet with a screen inside or gloves fitted with sensors ([McMillan, Flood, and Glaeser](#), 2017).

.XLSX is a format for Microsoft Excel documents that was introduced by Microsoft ([Aspose Pty](#), n.d.h).

10 Further Reading

For an introduction to the stakeholders, foundational archival concerns, and current efforts to collect, process, preserve, and provide access to born-digital design records, see the 2018 Library of Congress report from the *Designing the Future Landscape: Digital Architecture, Design & Engineering Assets* summit ([Leventhal, 2018](#)), Tessa Walsh's assessment of user practices in the CCA Access to Born-Digital Archives User Survey ([Walsh, 2017](#)), and the forthcoming *Born Digital Design Records* three-module series edited by Samantha Winn and Stacie Williams (Winn and Williams, Eds, forthcoming). These resources address both broad and granular questions around interpreting and accessing born-digital design records. For further exploration of the tacit knowledge captured in the infrastructure of born-digital files, albeit not directly speaking to born-digital design files, Eric Kaltman's article *Attending to Process and Data* is recommended ([Kaltman, 2020](#)).

Acknowledging there is a critical dearth of publications addressing digital visual literacy generally, and born-digital design records in particular, Anne Morgan Spalter and Andries van Dam's 'Digital Visual Literacy' presents the fundamentals of this competency, including an overview of its development from visual literacy ([Spalter and van Dam, 2008](#)). The forthcoming article 'Of Grasshoppers and Rhinos: A visual literacy approach to born-digital design records' outlines both the technical landscape of design software and practical steps to approaching born-digital design records with the intention of developing a digital visual literacy competency ([Ibid, 2021](#)).

Molly Wright Steenson's *Architectural Intelligence* offers a helpful overview of the symbiotic development of software design, architectural history, and the evolution of computer use in architectural practice (Wright Steenson, 2017). Daniel Cardoso Llach and Scott Donaldson offer a well-rounded assessment of the future potential born-digital design records and software collections hold for critical analysis of the born-digital design and construction processes ([Llach and Donaldson, 2019](#)). Henk Vanstappen successfully tests an approach for the archival community to work with the software/computer science community to describe and contextualize the development of a software and its file types in his report *SketchUp in digital archives Software and file format analysis and exploration of the options for digital preservation* for the Flanders Architecture Institute ([Vanstappen, 2019](#)). The Architekturmuseum der TU München's 2020 exhibition *The Architecture Machine* provides both a robust discussion around interpretation of design projects created in design software and represented through born-digital design files and valuable timelines for the development of different categories of design software ([Architekturmuseum der TU München, 2021](#)).

To remain abreast of the ever-changing design software landscape requires proactive measures. Consider subscribing to Shaan Hurley's blog *Between the Lines*, which offers a wide range of updates about Autodesk products and community in addition to rich documentation of the history of Autodesk products. There are also relevant organizations, such as the American Institute of Architects (AIA) and the Association for Computer Aided Design in Architecture (ACADIA), who have yet to be directly engaged in conversations amongst archival professionals but offer a wide range of papers and news articles on the developing research and practices with born-digital design files.

The scope of this report was heavily influenced by the DPC briefing day 'Building a Digital Future: Challenges and Solutions for Preserving 3D Models', the presentations from which are available from the event web page ([Digital Preservation Coalition, 2020](#)).

Other titles in this series of DPC *Technology Watch Reports* may also be of interest, in particular *Preserving Computer-Aided Design (CAD)* ([Ball, 2013](#)), *Preservation Metadata* (2nd edition) ([Gartner and Lavoie, 2013](#)), *Preserving Geospatial Data* ([McGarva, Morris and Janée, 2009](#)), and *File Formats for Preservation* ([Todd, 2009](#)). Additionally, several DPC Guidance Notes offer helpful insights on related topics including *Preserving Software: Motivations, Challenges and Approaches* ([Morrissey,](#)

2020), *Developing an Access Strategy for Born Digital Archival Material* (Dietz and Peltzman, 2021) and *Preserving CAD* ([Artefactual Systems and DPC](#), 2021).

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