MIT Libraries
Proposal to the Institute for Museum and Library Services
Future-Proofing Architectural Computer-Aided Design (FAÇADE)

Narrative

1. Assessment of Needs

Cultural memory institutions (particularly libraries, archives, and museums) have a long-standing responsibility to collect, curate and preserve materials related to the history and practice of architecture and design. These collections support scholars in many fields of study. For centuries these organizations have kept records of building design drawings, blueprints, specifications, models, and other material that tells the story of a building's conception, construction, and final form. While this curatorial responsibility has in no way diminished in the digital age, the means of accomplishing this mission are changing dramatically.

Over the past forty years, architecture and design professionals, like most other professions, have begun to depend on computer software to support their work and to drive innovation in their field. In particular, Computer-Aided Design software has become an absolute necessity for the performance of architecture and design work, and has, in fact, transformed contemporary architecture.

> "Computer-aided design (CAD) is the use of a wide range of computer-based tools that assist engineers, architects and other design professionals in their design activities. It is the main geometry authoring tool within the Product Lifecycle Management process and involves both software and sometimes special-purpose hardware. Current packages range from 2D vector based drafting systems to 3D parametric surface and solid design modellers.
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> …The software package may produce its results in several formats, but typically provides a graphically-based result which is then able to be used to create concept sketches for assessment and approval, and eventually working drawings. An example would be a structural design package used to assess the integrity of a steel-framed building by performing all the calculations necessary to determine the size and strength of the components, and the effect of such things as wind-loading. The output commonly is a schedule of materials and some basic sketches which can be transferred to a computer-aided drafting package for final production of construction working drawings.
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> Computer-aided drafting, however, commonly refers to the actual technical drawing component of the project, using a computer rather than a traditional drawing board. The input into this aspect of the design process may come from specialised calculation packages, from pre-existing component drawings, from graphical images such as maps, from photos and other media, or simply from hand-drawn sketches done by the designer. The operator's task is to use the CAD software to meld all the relevant components together to produce drawings and specifications which can then be used to estimate quantities of materials, determine the cost of the project and ultimately provide the detailed drawings necessary to build it.
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> The spectrum of architectural and engineering projects commonly documented with computer-aided drafting is broad, and includes architectural, mechanical, electrical, structural, hydraulic, interior design, civil construction. CAD may also provide input to other forms of design communication such as 3D visualisations, model construction, animated fly-throughs, to name a few.
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> Computer-aided drafting software is also a basic tool used in other disciplines related to Architecture, for example Civil Engineering, for site design, for instance roads, grading and drainage, in mapping and cartography, in the production of plans and sketches for a variety of other purposes (such surveyor's plans

and legal descriptions of land), and as the input format to geographic and facilities information systems. Additionally, landscape architecture and interior design is often also commonly performed using CAD software"

From Wikipedia, 2005 http://en.wikipedia.org/wiki/CAD

The beginning of widespread adoption of Computer-Aided Design software for industrial design was the result of research at MIT in 1963 which led to the SKETCHPAD software for graphical input into a computer-based modeling system. The initial focus of CAD adoption at that time was to use computers to produce two-dimensional design drawings which could later be printed out in various ways, and this is still the most common practice in architecture and other design-dependent industries. These architects and designers create printouts (the "as-built" drawings) for their archives and do not attempt to keep the digital 2D design files. Increasingly, however, more complex 3D CAD models (i.e. parametric, kinematic, solid, etc.) are being created, particularly in the more advanced and pioneering architectural firms – exactly those we should be capturing for the future.

The market for CAD software is still evolving and there are many CAD software products currently on the market, but more than half of the market is however covered by four corporations: Autodesk, Dassault Systemes, PTC, and UGS Corp. In architecture Dassault Systemes leads the rest with their high-end 3D hybrid drafting and solid surface modeling software, CATIA®.

Forty years after the introduction of CAD software MIT completed construction of the Stata Center[1], a new building on its campus designed by Frank Gehry. Gehry is one of the world's leading architects, and was a pioneer in the use of three-dimensional CAD software as an integral part of contemporary building design by his use of the CATIA design software starting in the early 1980's.

Figure 1: Frank Gehry, *MIT Stata Center*, 2004. Cambridge, Massachusetts.

CATIA at Frank O. Gehry & Associates, In.

"This technology provides a way for me to get closer to the craft. In the past, there were many layers between my rough sketch and the final building, and the feeling of the design could get lost before it reached the craftsman. It feels like I've been speaking a foreign language, and now, all of a sudden, the craftsman understands me. In this case, the computer is not dehumanizing; it's an interpreter." ...Frank Gehry[2]

[1] See http://en.wikipedia.org/wiki/Stata_Center for general information, and the article in Wired Magazine 12(05) May, 2004 "Frank Gehry's Geek Palace", http://www.wired.com/wired/archive/12.05/mit.html for more detail

[2] Case Study of CATIA at Frank O. Gehry & Associates, Inc. http://www.cenitdesktop.co.uk/html/case_frank_gehry.htm

Figure 2: Frank Gehry: *Museo Guggenheim*, 1997. Bilbao, Spain.

CATIA and its competitors (for architecture, primarily AutoCAD® from Autodesk and Microstation® from Bentley Systems, Inc.) store and export data in proprietary file formats. For example, AutoCAD uses the DWG format internally, and it has become a de facto industry standard [CSA] but Autodesk changes the format with each new release of their software and has no motive to maintain backwards compatibility with older versions. Autodesk also created the DXF export format, a standard drawing interchange file format that allows import of AutoCAD files into other software packages, but it is owned by Autodesk and is so flexible that in practice interoperability is not guaranteed. A significant issue with current interchange formats is that they do not capture all the information needed or available from the native software in order to fully interpret the intentions of the designer (i.e. they make simplifying assumptions, translation errors, and so on) [CSA].

A new trend in architecture is the use of comprehensive Building Information Models (BIMs) that include non-graphical data (about materials used, and so on) and are used to structure communication among different disciplines in the design and construction team. Unfortunately, no standard formats exist to represent these BIMs and a problem with current CAD software is its lack of support for capturing this building *process*. To really insure that important design and construction decisions are captured and stored as part of the historical record, CAD files should be able to support annotations linked to their relevant components. A development that may help with this problem is the proposed ISO STEP standard for product data representation and exchange[3] which is intended for commercial products, but further analysis is needed to understand how well the standard applies to architecture and to preserving CAD material over time. While some software programs do support attaching related material to the CAD files (for example, databases of building materials used) but they do so in ad hoc ways that only increase the difficulty of curating and preserving the material over time.

Another aspect of the problem is the *complexity* of digital CAD output. A single CAD model is often composed of dozens or hundreds of individual files representing different "layers" of the model and all interrelated in important ways. Each CAD software platform has a unique way of dealing with these complex data objects, and none of them export the data in a way that retains the relationships between the individual files so that subsequent use of the output files is quite restricted. Furthermore, there are often several CAD models that are

[3] http://www.tc184-sc4.org/SC4_Open/SC4_Work_Products_Documents/STEP_(10303)/

created and used during the building process, starting with the architect's original model and ending with (usually simpler) models used by the construction company and materials suppliers. These CAD files also have important relationships to each other that are not represented by the data or in any standard way across projects.

Related Research

Research on long-term preservation of digital material is progressing rapidly thanks to a growing awareness of the enormity of this problem by both funding agencies and the public[4]. But some types of digital material have been relatively neglected in the research to date, and CAD models and drawings are among them. This is most likely because the creators of CAD files view the finished product (building, airplane, car, chair, jacket, and so on) as the "object of preservation" rather than the design documents that came before. However historians, sociologists, urban planners, facilities managers, safety regulators, and a host of others do need to be able to study the original models and plans, and increasingly a paper printout is not sufficient to really understand the finished product. Then there are products that never are finished (e.g. a model for a building that is never built[5]) or buildings that are lost (e.g. New York's World Trade Center). While the designers and planners may not have an ongoing need for the CAD models, others do.

In non-architectural uses of CAD there is a bit more activity. Two recent projects in particular are poised to make progress on aspects of this problem. The first research project based in the United Kingdom called "Immortal Information and Through-Life Knowledge Management (IITKM): Strategies and Tools for the Emerging Product-Service Paradigm"[6] is examining how to model, capture and preserve product design information for engineering companies that make heavy use of CAD (e.g. aerospace, defense, automotive, etc). The project is based at the University of Bath and is affiliated with UKOLN, a center of expertise in digital information management, providing advice and services to the library, information, education and cultural heritage communities in the UK[7]. FAÇADE project staff will evaluate the goals and findings of this project to understand how it might apply to architectural CAD files under management by cultural heritage institutions.

The second is a project funded by the Library of Congress's National Digital Information Infrastructure and Preservation Program [NDIIPP] through its research program, and that project is addressing similar issues of archiving CAD models (both two and three-dimensional) for long-term preservation, but with a focus on traditional products of engineering. The project is just starting up, and no particular archiving platform is yet defined for the project, and there is an opportunity for collaboration around the different types of CAD models and a common archiving platform[8]. The NDIIPP project is working on syntactical modeling options (standard XML-based and Semantic Web) that would be of interest to FAÇADE, and our work with the CAD software companies such as Dassault Systemes should be of value to the NDDIPP work.

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[4] Examples include the US National Digital Information Infrastructure and Preservation Program (http://www.digitalpreservation.gov/) at the Library of Congress, the US National Archives Electronic Records Archive (http://www.archives.gov/era/), and the UK Digital Curation Centre (http://www.dcc.ac.uk/) and many other such programs exist world-wide.

[5] The early 20th century modernist architect Mies van der Rohe is well known for having produced far more designs than actual buildings, and without those unimplemented designs architectural historians and students would be far poorer.

[6] For more information about this project, visit the project website at https://www-edc.eng.cam.ac.uk/kim/ and http://gow.epsrc.ac.uk/ViewGrant.ASPx?Grant=EP/C534220/1&bannerlink=Programme%20support

[7] UKOLN http://www.ukoln.ac.uk/ is led by Dr Liz Lyon, and has been a frequent collaborator with the MIT Libraries on projects related to digital preservation, information discovery, and digital library infrastructure.

[8] Drexel University Library uses the DSpace platform for its digital research archive, see http://dspace.library.drexel.edu/index.jsp

An important project in this area that is related to architecture was led by the Department of Architecture at the Art Institute of Chicago (AIC)[9] and Kristine Fallon Associates, Inc.[10] Driven by concern about the future of the documents they collect for "unbuilt projects", they conducted a study in 2004 of the current state of digital design tools and data used by design firms including architectural firms. They developed detailed recommendations for "best practices" related to the production of preservable outputs of the design process – i.e. PDF/A formatted documents and uncompressed TIFF formatted images – which can be deposited into preservation archives, specifically DSpace. Their recommendations are based heavily on the OAIS[11] and are up-to-the-minute where digital preservation best practices are concerned, but they go no further. In particular, they start with the assumption that the native CAD files, given their complex, non-standard, and completely proprietary nature, are not preservable. They recommend keeping the native files along with their more standardized and preservable by-products, but without any expectation that those native files will be usable in the future. The 2004 study has led to a funded project at the AIC to implement the practices they recommend using the DSpace platform and to extend it as described by the report.

While the AIC project does represent the best that can be hoped for right now, it does not really preserve what practicing architects (who desire reusability of their models), architecture instructors, architectural historians, and others need who want the "real thing". FAÇADE will pick up the research at that point, and will work with the AIC project team to complement and extend their work to the benefit of both.

No other significant projects working on long-term preservation of CAD, and especially three-dimensional architectural CAD models, have been discovered during the background research for this proposal.

2. National Impact and Intended Results

The previous discussion of the dependency of the architecture profession on CAD software and digital files serves to illustrate the problem that libraries and museums face in collecting and preserving the record of contemporary architecture. Best practices for preserving architectural records involve changing the practice of architectural and design firms to supply standard digital output formats such as PDF documents or TIFF image files rather than, or in addition to, the native data since no one has any idea how to preserve the native data over time [Fallon]. Preserving only standardized output formats, though, has significant deficiencies for the goals of historians, planners, and others

- A library, museum, or archive typically receives the records of the building project *long after the project's end*. By that time the information available is whatever was kept, and the architect is no longer available to translate their work into preferred output formats. If architectural and design firms begin to standardize their practices to always keep preferred output formats and important related material then this concern may diminish, but that is unlikely to happen any time soon.

- Output formats necessarily compromise on what information is transferred over from the native format, leading to a *loss of information*. Since each CAD program has its own method of describing geometry,

[9] Art Institute of Chicago, Department of Architecture http://www.artic.edu/aic/collections/arch/index.php

[10] Kristine Fallon Associates, Inc. http://www.kfa-inc.com/ led the 2004 study and is collaborating on the follow-on implementation project

[11] The Reference Model for an Open Archival Information System http://ssdoo.gsfc.nasa.gov/nost/wwwclassic/documents/pdf/CCSDS-650.0-B-1.pdf

both mathematically and structurally, output formats fail to capture the complete record of information related to the design and construction of the final structure.

- The *process information* is still missing from the archived collection, making reconstruction of the entire life cycle of the building from conception onwards quite impossible for historians and regulators.

The research problems are thus:

- What techniques can and should be applied to preserve the *native* CAD architectural models over archival timeframes? Given that CAD files require particular versions of specific software programs to interpret them, is it necessary and sufficient to archive the software as well, or is an "emulation" framework[12] needed for the digital archive platforms that host the material?

- What additional *process* information is needed to capture the entire building life cycle, and how can that information best be stored in digital archives? Is a new standard necessary for encoding that information, or is a linked document sufficient?

- What other *annotations* need to be supported to capture the architect's intentions and instructions to the contractors and subcontractors who do the construction (i.e. the Building Information Model) and where and how should that information be kept?

- How can we archive this type of data into *institutional digital repository systems* like DSpace, which are designed to cover the entire range of digital data formats that libraries, archives and museums need to manage and preserve?

Architectural practice – both in the US and globally – is currently going through a period of revolutionary transition. Traditional processes of design by means of drawings and physical models, and even with 2D computer drafting technology, are rapidly giving way to processes that are organized around large, sophisticated, 3D digital models. Some architects of major historic importance, such as Frank Gehry, are leading the way in this transition, and their most significant works are inseparable from this new approach. Archival practice has not kept up with this, with the result that records of enormous long-term historic value are not being systematically preserved, and are in imminent danger of being lost forever. This project will address the urgent need of developing effective, practical, generalizable approaches to preservation of architecture's emerging digital patrimony, and it will assure that some of the most important existing material is carefully preserved at MIT and elsewhere.

<u>Adaptability</u>

Many cultural memory institutions (e.g. libraries, museums, and archives) include holdings of material related to architecture and design, either as a general collection area or for the records management requirements of their particular institution[13]. Findings related to CAD format representation information (i.e. the technical

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[12] One approach to this, for example, is to automatically convert the data model into Virtual Reality Modeling Language (VRML) which is an XML Schema for representing 3D models that allows users to view the model in common web browsers. While such an approach would lose much of the functionality of the original 3D CAD model, it would be similar to the current approach of "printing out" 2D CAD drawings so that they can be read in the future. If such a conversion tool could be devised, it would be possible to extend the DSpace application layer to include a rendering plug-in for these models.

[13] Most organizations, including businesses, universities, and government agencies, keep architectural and building plans (including floor plans) as part of their standard records management practices.
http://www.archivists.org/governance/guidelines/museum_guidelines.asp (Museums store architectural plans in their archives)

properties of the file formats needed to preserve them over time) and specific preservation strategies will be of general application to all of these organizations within their own preservation environments. By adding CAD file format definitions to the Global Digital Format Registry the information will be commonly available in a standard, well-known location that includes tools to interoperate with a variety of preservation environments including DSpace.

Additionally, the DSpace digital repository open source software system will be enhanced to support CAD material according to the preservation strategies defined by this project, as well as improved to support digital preservation in general, and these enhancements will be made available to the entire DSpace user community as soon as possible following the conclusion of programming work.

DSpace is a freely available, open source software digital repository system to capture, store, index, preserve, and distribute digital research material. It was originally created by the MIT Libraries and HP Labs for a research project, and was released as open source software in late 2002. DSpace was designed to reflect the OAIS reference model for digital preservation archives, and has a number of features to support digital information life cycle management and digital preservation activities. Like most present day platforms with ambitions to preserve digital content over archival time frames, DSpace has good support for "bit preservation" of all formats (i.e. insuring that files persist over time and can be found and retrieved intact at any point in the future), and mixed support for "functional preservation" (i.e. insuring that a digital file can be viewed or played in the future exactly as it could when it was deposited, despite the obsolescence of its original technical file formats and/or authoring software). Some file formats, such as PDF/A and TIFF, are widely believed to be easy to preserve functionally since they are well documented, standard formats in common use. Other formats, such as those produced for video games, dynamic or interactive documents, or complex CAD models, will probably require a lot more work to preserve, either at the point of deposit into the archive by "normalizing" them into a common application framework like the UVC[14] or Multivalent browser[15], or by writing emulators for them in new platforms like DSpace. FAÇADE would devote significant effort to exploring this latter category of dynamic content that does not lend itself to standard, "easy to preserve" formats but which is of high value to keep for future scholars, and how to support that in the DSpace platform.

The DSpace user community that would benefit from this work is described in detail on the project website[16] and is a large, world-wide group of organizations, primarily research universities that seek to make accessible and preserve their intellectual resources in digital formats created by local faculty, students, and researchers. There are approximately one hundred and fifty registered institutions using the DSpace software today[17], and

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http://www.nationalarchives.gov.uk/recordsmanagement/pdf/news_oct03.pdf "However this [preservation of twentieth century architectural plans on fixed media] will be a finite problem as, in the Twenty-first Century, architectural plans will no longer be produced in a physical format, but drawn and displayed virtually on computer screens. And stored on floppy-disks, CD-ROM and whatever other formats are developed over the next few decades. The preservation and storage of virtual material is the next challenge." (Brian Thomas, Conservation Manager, UK National Archives, in Records Management News, October 2003).

[14] Universal Virtual Computer, a concept first developed by Raymond Lorie at IBM and subsequently implemented by IBM and others (http://www.alphaworks.ibm.com/tech/uvc)

[15] The Multivalent Browser was first developed at Berkeley by Dr. Robert Wilensky and a graduate student, Tom Phelps, and has now been further developed and extended to include additional formats by Dr Phelps at the University of Liverpool http://multivalent.sourceforge.net/

[16] http://dspace.org

[17] For the current list of registered, live DSpace repositories see http://wiki.dspace.org/DspaceInstances and there are additional repositories that did not choose to be publicly registered.

there is a mature process in place to govern and enhance the software for new features such as those proposed for this project[18].

Of particular note is that the DSpace community includes many research libraries, including the MIT Libraries, but also a number of museums[19] and archives[20]. The applicability of this project's findings will go well beyond the higher education and research university domains, and will also have broad input from practicing architectural firms and archives.

3. Project Design and Evaluation Plan

The FAÇADE project has five major objectives:

- Analysis, identification and description of native digital formats produced by top CAD software used by architects, primarily CATIA and AutoCAD formats. Registration of these formats into the Global Digital Formats Registry for general access.

- Analysis, design and implementation of native CAD file *ingestion, management, preservation and dissemination* practices, and development of necessary modules for the DSpace digital archive system. These may include archiving of relevant CAD software packages for future processing, or development of emulation tools and frameworks for rendering these files in the DSpace platform at a minimum.

- Analysis and recommendation related to *process* documentation (relationships between various CAD files and versions, and between CAD files and other project communication and documentation).

- Analysis and recommendations related to *annotation* of CAD files for important related information, such as non-graphical files related to materials used.

- Documentation, training, outreach and dissemination of results to the digital library, digital preservation, and DSpace user communities

FAÇADE proposes to focus quite closely on CAD as applied to architecture projects, and so we will begin with a significant collection from a recent MIT-based project to build the Stata Center[4]. The collection in hand includes:

- Various 3D CATIA CAD models developed by Frank Gehry, including the final approved model for the Stata Center. The version of CATIA used to produce these models has already been superseded and these files are already at risk of permanent loss.

[18] Instructions for contributing code to DSpace are well documented on the project site http://wiki.dspace.org/HowToContribute, and MIT, as the originator of DSpace with HP Labs, has staff dedicated to managing this process so that we run a very low risk of rejection of any software improvements we contribute. We also have a strong track record for documentation, training and outreach of our modifications to the platform so that other institutions can benefit from the work.

[19] For example, the American Natural History Museum in New York (http://digitallibrary.amnh.org/dspace/) or the China Digital Museum Project (http://wiki.dspace.org/ChinaDigitalMuseumProject) which includes several major university-based museums in China as well as the Chinese Ministry of Education.

[20] For example, the Kansas State Historical Society http://www.kspace.org/

- Various revisions of the 2D AutoCAD files corresponding to all the different phases of the project and evolution of the construction drawings, and thousands of pages of printed drawings in the complete set (note that there are hundreds of files associated with a single "drawing") and 16 official "drawings" that were part of the project. The version of AutoCAD that was used to produce these files has since been superseded and these files are already at risk of permanent loss.

- Hundreds of digital photos from both the design phases (e.g. model shots) and actual construction. These can be archived using standard practices, and then linked to the CAD models and drawings.

- Many other design communications (ASI, Sketches, RFIs, Deviation Requests, etc.). Many of these were created by communication systems (Citadon and Buzzsaw) which are no longer used since the project's completion, but the communications themselves can still be extracted for transfer to a preservation environment. These communications can be used to study the requirements for Building Information Models and other process annotations that the product life cycle requires.

For this phase of the project we will work with Dr. Christopher Terman, the MIT departmental project liaison to FOG/A (Gehry Partners, LLP), who collected the CAD and other material related to the Stata Center design and construction project. We will also work with FOG/A principals who have access to additional data and who can grant us the necessary intellectual property rights to archive and make available this material (see letter of support).

Subsequent phases of the project will expand the research to include other project documents from the Gehry Partners' archives, and other architectural firms that we will contact via Professor Mitchell (the project's co-PI) and members of the MIT Department of Architecture. These additional collections will test our findings and archiving methodology for the Stata Center collection, and lead to generalized procedures and documentation that can be shared with the cultural history community.

<u>Project Evaluation</u>

Project deliverables include CAD preservation strategies and software to support them that will run, minimally, in the DSpace platform. Tests of CAD document usability in the DSpace preservation environment will be demonstrated to show transportability of CAD data over time. Input on requirements for preserving CAD models for architectural history and for preservation strategies will be solicited broadly from architects, educators, historians, librarians, archivists, and digital preservation experts.

4. Project Resources: Budget, Personnel and Management Plan

The project budget will be monitored by the Libraries' Assistant Director for Administration, with support from the Administrative Assistant in the Digital Libraries Research Group and the Financial Administrator in the Libraries' central administration. The Libraries' Personnel Administrator, together with the Assistant Director for Administration, will oversee personnel actions such as performance and salary reviews. Together, these staff will support the Principal Investigator in all administrative functions needed to implement and maintain a research project of this scale at MIT.

Project management will be performed by the Principal Investigator at the MIT Libraries and co-PI from the MIT Department of Architecture, working together with the Project Manager and other project staff. The MIT Libraries Digital Library Research Group has a strong track-record of successful completion of significant research projects, a list of which is provided in attachment VI.

<u>Project Personnel</u> *(see Attachment V. for Personnel Resumes)*

Principal Investigator (.20 FTE)
MacKenzie Smith, Associate Director for Technology, MIT Libraries

Co-Principal Investigator
Dr. William Mitchell, Alexander W. Dreyfoos Professor of Architecture and Media Arts and Sciences.

Project Manager (.5 FTE)
William Reilly, Technical Project Manager, Digital Library Research Group, MIT Libraries

Data Analyst/Programmer (.5 FTE)
Grace Carpenter, DSpace Programmer, Digital Library Research Group, MIT Libraries

DSpace Systems Analyst/Programmer (FTE)
Larry Stone, DSpace Programmer, Digital Library Research Group, MIT Libraries

Dept of Architecture liaison (.15 FTE)
Ann Whiteside, Director, Rotch Library

Dept of Architecture Data Analyst (.5 FTE)
PhD student from the Department of Architecture, to be hired

Stata Center Project Liaison
Dr Christopher Terman, Senior Lecturer, Dept. of Electrical Engineering and Computer Science. Liaison for Stata Center archival material

5. Dissemination

Technical information discovered about various CAD formats will be recorded in the Global Digital Format Registry for universal access and reuse. Software developed for the project will be made available via standard Open Source Software licenses[21] and, where appropriate, will be distributed with the DSpace Open Source software platform or as a separate module for downloading. All other project results will be disseminated via standard communication channels to the DSpace community (e.g. presentations at annual user group meetings), to the digital library, archives and preservation communities via articles and presentations.

6. Sustainability

The project's primary deliverables are strategies for preserving 3D CAD models and software that can be distributed with the DSpace open source software platform. DSpace itself has a well establishment plan for sustainability, so project results can be folded into that plan without additional resources in the future.

[21] MIT Libraries code, including DSpace, is distributed with a BSD open source license http://www.opensource.org/licenses/bsd-license.php that allows for any type of reuse.