Curating Architectural 3D CAD Models

FACADE

Future-proofing Architectural Computer-Aided Design

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MIT Libraries

Society of American Archivists Meeting
Architectural Records Roundtable, August 12, 2009
Problem Statement

- Current architectural data is being lost.
- CAD (3D) is complex!
  - Highly proprietary, non-standard, backwards incompatibilities, obsolescence of software and formats
- 3D digital preservation new territory
  - Lack of tools, standards, approaches
FACADE Project

- IMLS grant
  - 2-year (Sept. 2007 – Sept. 2009)

http://facade.mit.edu
FACADE Project Staff

- William Reilly (wreilly@mit.edu)
  - Technical Projects Manager, MIT Libraries
- MacKenzie Smith
  - Associate Director for Technology, MIT Libraries
- Ann Whiteside
  - Head, Rotch Library for Art and Architecture, MIT Libraries
- William Mitchell
  - (former) Dean, MIT School of Architecture and Planning
FACADE Project Proposal

- Develop optimal long-term archiving strategy for digital architectural data
  - Especially 3D CAD models
- Demonstrate in DSpace digital archive
  - With SIMILE user interface discovery tools
- Use Frank Gehry MIT Stata Center dataset
  - Advanced 3D CAD tool CATIA
Architecture Data Producers: the landscape
Data Producers: Architecture Firms

- Technology
  - Design
  - Communications, Management
- 3D CAD increasing in complexity
  - “BIM” recent initiative (Building Information Modeling)
  - Lacking standards for use, naming, interoperation
Building Information Modeling

Building Information Modeling Opportunities

Geospatial Info

Product Selection

Fabrication

Invoicing/Payment

Ordering/Delivery

Computerized Maintenance Management System (CMMS)

Planning

Design

Construction

Operations

Sustainment

Legal Info

Engineering Analysis

Code Compliance Checking

Computer Aided Facility Management
What are Firms Doing, re: CAD, digital data?

- Not So Good (status quo):
  - Creating lots more CAD every day, but unorganized
  - Continuing to rely on proprietary formats for current and mid-term purposes
  - Not archiving for long-term
  - Not preparing (don’t know how) materials for archive
What are Firms Doing, re: CAD, digital data?

- Good (progress):
  - (Beginning to) recognize the issues
  - Attempting to make data interchange standards work
  - Trying to embrace BIM: richer CAD might aid interchange efforts, heighten need for longer-term archive solution
Data Consumers: Audiences

- Practice (Architects, Designers, Engineers)
- Research (Historians, Scholars)
- Teaching (Instructors, Students)
- General (Public, Casual)
Use Cases

- Practice (Architects, Designers, Engineers)
  - (Internal) Perform current work; re-use recent work
  - (External) Data interoperation with partner firms
  - ("Read Only") Consult own work

- Research (Historians, Scholars)
  - (Design) Study history of design, "design intent"
  - (Business) Study process, techniques, economics

- Teaching (Instructors, Students)
  - (Design) Study history of design, "design intent"
  - (Practice) Study models to learn, extend CAD
  - (Computation) Capabilities, constraints, on design

- General (Public, Casual, Educational)
  - Study architectural history; view buildings, designs

Blue signifies future use cases.
Audiences Consulted

- Advisory Board
  - Architectural historian
  - 3D engineer
  - World cultural heritage
  - Architecture faculty
  - Practicing architects
  - CAD researcher
  - Architecture CAD platform CIO
  - Architecture IT consultant
Audiences Consulted

- MIT School of Architecture Faculty and Students
- Architecture firms (architects and librarians)
- DCC 3D preservation seminars
- AIA Congress workshops
- CAD vendors discussions
The Content (Data)
Datasets for Project

- Frank Gehry, MIT Stata Center
  - CATIA

- Moshe Safdie, U.S. Institute of Peace
  - Revit

- Thom Mayne, Caltrans
  - Microstation
Data and “Meta” Data

- 10Ks of files
- 10s of Gbs
- 100+ file formats
- File system
- Almost no metadata
- Collab. systems
Entire data set

Entire architecture/design *project*

- Initial sketches
- 3D CAD models, 2D CAD drawings
- Formal outputs (e.g. client presentations)
- Correspondence, RFIs, ASIs, etc.
- Consultant reports, obligatory certificates, documents
- Images, video, other media files
- Every client issuance
3D CAD

- Data Formats; Standards; CAD Tools
- Preservation Strategies
Terminology: Geometry

- **NURBS**  “Non-Uniform Rational Basis Splines”
  Freeform curves, surfaces. Weighted points

- **Mesh**  Collection of vertices, edges and faces

http://en.wikipedia.org/wiki/Nurbs
http://en.wikipedia.org/wiki/Polygon_mesh
Terminology: Parametric

- **Parametric**
  - CATIA
  - Revit
  - Microstation

- **Non-Parametric**
  - Rhino
  - Maya

“Features” vs. just underlying geometry
3D CAD Systems in Architecture

- Dassault Systemes’ **CATIA** (Stata Center)
- Autodesk’s **Revit** (U.S. Inst. Peace)
- Bentley’s **MicroStation** (Caltrans)

- Vary in parametric modeling v. inert geometry support
- Vary in complex (NURBS) v. simple geometry (Mesh) support

*How CAD products encode geometric and parametric models is unique and proprietary*

- Project deliverable: format representation information
Data Exchange Formats

- Open, Standards-Based
  - Model Information
    - **STEP (ISO 10303)**
    - **IFC (ISO 16739)**
  - Geometry Information
    - **IGES**
    - **VRML**
    - **STL**

- Display formats (generally available)
  - **3D PDF**
  - Flash

- Various Industry Data Exchange Solutions
  - **Navisworks**
  - **Collada**
  - **DXF / DWF**
  - **DWG / DGN**
  - **Viewers**
  - ...

Blue signifies formats under study.
“Viewing” of data

- In native-format with user’s CAD software
- As “static” PDF
3 Derivative Formats: IGES, STEP, 3D-PDF
IFC Viewer: Solibri
3D PDF: Quick Look
3D Model Interactivity

If CAD software only exports *inert geometry*, the original parametric model is lost – i.e. the preservable artifact is not authentic

*Does that matter? To the project audience...probably not... to us...yes?!!*

- Doesn’t fully represent design intent
- Can recreate a parametric model later
- Can manipulate the model view (e.g. 3D PDF)
How to sort through and manage all that data?
The Project Work and Tools

- Project Information Model, Workflow
- Metadata, “Curators Workbench”
- DSpace Archive
Managing the data intellectually
Ontology

Working from BIM Idea

Created a project information model utilizing RDF

RDF: Resource Description Framework

http://www.w3.org/RDF/

An ontology system using XML to exchange knowledge on the Web (part of the semantic web movement)
PIM - Project Information Model

Entire architecture/design project

- Initial sketches
- 3D CAD models, 2D CAD drawings
- Formal outputs (e.g. client presentations)
- Correspondence, RFIs, ASIs, etc.
- Consultant reports, obligatory certificates, documents
- Images, video, other media files
- Every client issuance

Linked together in a relationship map
the Project Information Model
_sort and classify all the available data - 2d, 3d and construction
administration (RFI's, change orders) - and map their relations. Model this
as an ontology that can be called in an environment such as DSpace or the
semantic web.
this formalization of building components is required so that they can be
linked/represented in a predictable structure. In this manner, a reasoning
methodology can be applied to other works.

* F. Gehry establishes and maintains his own
contract separate from Gehry Partners
Prototype Two
(latest approach)

Every *File* gets five properties

- Project Phase
  e.g. concept, design, construction, etc.

- Building Zone/System
  e.g. Stata Center, Gates Tower, 4th floor

- Architectural Discipline
  e.g. architectural, electrical, mechanical, structural

- Document Type
  e.g. presentation, drawing, communication

- File Format
  e.g. CATIA, AutoCAD, Word, PDF
Properties on Objects [2 of 2]

- *Important files* further tagged
  - Specially curated “*Selected Objects*”
    - 3D models and 2D drawing sets
    - Client presentations, etc.
  - Privileged access in user interface
Managing the data “physically”

- Metadata
- Storage
## ConcordFormat

Concordance "How To" Page

## Merged Format Concordance for FOG/A

Frank O. Gehry's Stata Center

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http://libstaff.mit.edu/facade/index.php/ConcordFormats
Curators’ Workbench (CWB)

- File object properties assigned
- Selected Objects identified
DSpace Archive

- Preservation, dissemination, access control
- FACADE UI external to DSpace
- Bulk ingest tools (e.g. Curators’ Workbench; DSpace “packager” importer)
- Format registry integration for technical curation (GDFR, PRONOM, DSpace internal)
The “Archive”

Result of current work:

Creating a research/teaching archival collection, not a records repository.
User Interface

- SIMILE “Exhibit”
- SIMILE “Longwell”
SIMILE tools

- SIMILE
  - http://simile.mit.edu/
    - Exhibit and Timeline tools
    - Publishing framework for web display
- Longwell
  - RDF-based faceted browser
  - http://simile.mit.edu/wiki/Longwell
### FACADE PROJECTS

#### The U.S. Institute of Peace Headquarters

- **Designed by**: Renowned architects Moshe Safdie and Associates
- **Symbolic Architectural Statement**
- **Visible along the capital skyline**
- **Environmentally-friendly and LEED certified**
- **Three distinct sections linked together**
- **Series of roof elements constructed of steel frames and white translucent glass**

#### Building Steel and Glass Features:
- **Roof feature**: Intimating the wings of a dove.
- **Cost**: $65,000,000
- **Building Administrative Building**: Government Facility
- **Type**: Government Facility
- **Contributor**: Unknown
- **Location**: Washington, D.C., U.S.A.

#### Architectural Expressionist Style:
- **Alternative USIP names**: Extent 150,000 square feet
- **Is built?**: False
- **Climate**: Humid Subtropical

#### Creator:
- Moshe Safdie and Associates
- Construction Steel, concrete System, and glass

#### Construction System:
- Custom perforated stainless steel panels attached to a tube steel frame bolted to concrete building frame.
- Poured-in-place concrete, custom steel frame, hand-set brick, custom

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Caltrans Project “Exhibit”: Tiles View
Exhibit: Timeline, with Popup, Download
Caltrans “Longwell”: “Starting Points” View

Caltrans District 7 Headquarters

Featured Data-Sets:
- Design Drawings, Models and Sets
- Photographs

Phases
- (missing) 13471
- Construction Documents 10373
- Design Development 1904
- Competition 512
- Pre-Schematic Design 506
- Schematic Design 380
- Post-Construction Documents 164
- Does Not Apply 2

Document Types
- (missing) 13485
- Drawing 10946
- Photograph 1641
- Communication 241
- Specification 201
- Presentation 132
- Work File 119
- Unknown 115
- Model 65
- Product Brochure 55
- Rendering 54
- Sketch 34
- Other 17
- Circularly Filed 3
- Agreement 2
- Index 2

Zones
- 13459 (missing)
- 13492 Caltrans
- 1344 Core Building
- 172 Plaza
- 131 Trellis
- Does Not Apply 3
- South Section 1

File Formats
- Microstation CAD 8758
- JPEG File 4708
- Interchange Format 1.02 3168
- AutoCAD Drawing 2000-2003 3055
- AutoCAD Drawing R14 1911
- ASCII Text 1084
- AutoCAD Shape/Font File 906
- Tagged Image File Format 3 496
- ISO8639 Text 488
- Hewlett Packard Vector Graphic Plotter File 396
- Adobe TrueType Font data 285
- Portable Document Format 1.4 249
- AutoCAD Colour-Dependent Plot Style Table 245
- OLE Object 7

Architectural Discipline
- (missing) 13482
- Architecture 13088
- Structural 412
- Interiors 102
- Security 67
- Food Service 38
- Plumbing 32
- Mechanical 26
- Signage 23
- Landscape 15
- Lighting 13
- Audiovisual 6
- Civil 3
- Electrical 2
- Does Not Apply 2
- Info Tech 1
### Caltrans District 7 Headquarters


#### Featured Data-Sets:

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**Design Type:** Model, Architecture, Competition, Caltrans

**Architectural Discipline:** Model Set, Architecture, Competition, Caltrans

**Phase:** Construction Document, Core Building

**Zone:** Caltrans
Longwell: Tiles View, Full Text Search; MS-Word .DOC

Caltrans District 7 Headquarters

Featured Data-Sets:
- Design Drawings, Models and Sets
- Photographs

Add View | Start New Search

21 item(s) in 3 pages.
Sort by FullText

Leed_Storage and Collection of Recyclables.doc

Architectural Discipline:
- Architecture

Document Type:
- Work File

Source:
- Caltrans LEED/Leed_Storage and Collection of Recyclables.doc

Format:
- Microsoft Word for Windows Document 97-2003

Filesize:
- 108032

MR Prerequisite 1: Storage & Collection of Recyclables

(Architect, Interior Designer or Responsible Party)
Thom Mayne

2041 Colorado Avenue
SANTA MONICA, California 90404

T: 310.453.2247
F: 310.829.3270

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www.morphosis.net
Outcomes of Project
(forthcoming...)

**INSTITUTIONS:**
- Open source, production quality software (repository; U/I)
- Preservation strategy, format info, for 3D CAD
- Ontology, workflow

**USERS:**
- Availability of materials
- Improvement over “File System” organization
- Some add’l. metadata
Challenges (an archivist’s view)

- Intellectual Property
  - Rights, Restrictions
- Access, Display
  - What will work, how will it work?
- Long-term Preservation
  - Software; digital preservation in general
- Sustainability
  - How support?
Next Steps
Next for MIT

- Evaluating work products
- Pursue follow-up grant
  - Focus on digital preservation of 3-D CAD
- Pilot Fall 2009
  - Analyze resources needed
    - Cataloging/curating
    - Programming/tech support
  - Issues (Access, IP, ...)

August 12, 2009 © MIT SAA, Architectural Records Roundtable
Final Comments

- Opportunities
  - Tools (ex. Curator’s Workbench) to address large “data” files
  - Interface developments
- Challenges
  - Scalability
  - I.P. hurdles
- Questions
  - wreilly@mit.edu; rosko@mit.edu
Acknowledgement

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The views and conclusions contained of this presentation are those of the author and should not be interpreted as representing the official policies, either expressed or implied, of the IMLS or the U.S. Government.

http://facade.mit.edu