Model Curation: Requisite Leadership and Practice in Digital Engineering Enterprises

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Dr. Donna H. Rhodes
Massachusetts Institute Of Technology
rhodes@mit.edu
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Motivation
Curation Practice
Model Curation and Curator Role
Enabling Methods
Future Directions
motivation

Models becoming increasingly valuable, leading to equal/greater value than physical asset

Need for composability of models for specific purposes beyond original use, requires knowledge depth and breadth

Modeling competency across individuals and programs, but not strategically developed/managed at enterprise level

Models exist at all levels of enterprise (individual, program, business unit) but seldom managed as enterprise collection

How can component models be represented, archived, maintained, and accessed to facilitate rapid integration?

Put simply, these resources need to be curated.

Rouse, 2015

THROUGH LIFESPAN

(digital twin)

operate

develop

design

MODEL REUSE

Longer Duration

April 2019
SEARI.MIT.EDU
Model curation is the **lifecycle management**, **control**, **preservation** and **active enhancement** of models and associated information to ensure **value for current and future use**, as well as **repurposing** beyond initial purpose and context.
other curation fields inform model curation

Museum curation
Digital curation
Content curation
Social curation
Data curation
Biomedical model curation

museum curator
- accessions
- valuation of assets
- strategic loan/acquire
- oversight of collection
- set collection policy/practices
- strategic planning
- leadership of special exhibits
observations from research on digital curation
NAS, 2015

Recent study concluded that digital curation is unique in regard to:

1. Immense and ever-increasing quantities of material to be curated
2. Need for active and ongoing management in a context of continually changing uses and technology
3. Great diversity of organizational contexts in which curation occurs

Digital curation

...allows users to understand and exploit digital information assets and to ensure their integrity over time

...ensures digital information remains discoverable, accessible, and useable for as long as potential users have a need or a right to use it.

Many challenges of digital curation also pertain to model curation
observations from research on curation of CAD engineering models
Patel et al. (2009)

Information to be dealt with are diverse and particularly complex, including product geometry, finite element analysis models, manufacturing process models, etc.

Engineering organizations need to communicate that information to a wide range of different stakeholders, each with different information needs and access rights.

Need for best practice guidelines and cost-benefit models to aid in choosing appropriate curation strategies since deciding a suitable path is non-trivial and contingent on many factors.
defining the role of model curator

**Model Curator:** a designated professional role entrusted with the ownership, tracking and use of model collection objects, and possessing designated authorities for managing and controlling models

Lexicon under development:

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
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<tbody>
<tr>
<td>Model Collection</td>
<td>The collection of model-based assets that is possessed by the enterprise, including those developed by the enterprise, acquired by the enterprise and temporarily resident in the collection (e.g., leased, on loan).</td>
</tr>
<tr>
<td>Model Collection Object</td>
<td>A model or model-related object that is a unique asset in the enterprise’s collection. An object is assigned a unique identifier.</td>
</tr>
<tr>
<td>Model Composition</td>
<td>The process of composing models and model-related information that provides collective value beyond the individual models.</td>
</tr>
<tr>
<td>Model</td>
<td>The characteristic of an interrelated set of models that enables them to be combined in accordance with given modeling frameworks.</td>
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model curation role at program-level

In some enterprises, selected curation activities exist at program level:
◦ Existing instances of curation-type responsibilities such as selecting and maintaining the set of models for a specific program or laboratory purpose

Envisioned role of a *Program-Level Model Curator*

◦ maintains program-owned models and information
◦ plans and manages modeling software version upgrades
◦ works with model software developers on specialized needs
◦ collaborates with configuration management and data management functions
◦ performs model trade-offs and model software selections
◦ organizes training for program staff
◦ supports enterprise-level model assessments and activities
◦ .....
envisioned Role: enterprise-level model curator

Enterprise model curator role aligned with the goals of the DoD Digital Engineering Strategy

DoD organizations must “formally develop, integrate and curate models”

model curator

- enterprise model accessions
- valuation of model and digital artifacts
- strategic loan/acq of models
- oversight of model collection activities
- set model collection policy/practices
- strategies for model-centric future
- leadership for model demonstrators
initial investigation of enterprise leadership organizational forms

<table>
<thead>
<tr>
<th>Form</th>
<th>Description</th>
<th>Chief Model Curation Office (CMCO) Organizational Form – under what conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Centralized –</td>
<td>CMCO is a top tier exec reporting directly to CEO</td>
<td>High performing model-centric engineering enterprise or enterprise that has a very aggressive goal to become one. Culture has fully embraced model-centric engineering across entire enterprise, and enterprise believes model leadership is key to competitive advantage and innovation.</td>
</tr>
<tr>
<td>Top Tier</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centralized –</td>
<td>CMCO has “dotted line” reporting CEO</td>
<td>The enterprise is rapidly becoming a high performing digital engineering enterprise. The CMCO needs enterprise level authority to implement strategic decisions, but enterprise is not ready to make CMCO a full member of the executive management team.</td>
</tr>
<tr>
<td>Dotted Line</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Franchised</td>
<td>Enterprise units have CMCOs, with common policies</td>
<td>For very large enterprises with top-tier CMCO. In a franchise or sub-division, its top executive, confers the overall CMCO role to a virtual CMCO. An appointed collaborative committee is “virtual CMCO” serving as a strategy-setting and oversight body.</td>
</tr>
<tr>
<td>Collaborative</td>
<td>Virtual CMCO role via collaborative committee</td>
<td>Enterprise does not wish to appoint single individual but recognizes need to have model curation capabilities. An appointed collaborative committee is “virtual CMCO” serving as a strategy-setting and oversight body. May be instance where this may be a preferred form is an enterprise comprised of many newer acquisitions that have strong heritage culture and processes.</td>
</tr>
<tr>
<td>Dual Hat</td>
<td>CMCO is one of two roles played by an executive</td>
<td>An enterprise that is working on multiple approaches; not ready to appoint CMCO; enables enterprise to allocate specific curation responsibilities to an existing leader (CIO, CTO, CDO)</td>
</tr>
<tr>
<td>Delegated</td>
<td>CMCO tasks delegated to one or more individuals</td>
<td>Similar to “dual hat” but role is not specifically delegated to one or more individuals. In an existing role, or to the responsibilities of a standing committee. This implementation is weaker than dual hat, but does acknowledge these responsibilities, as a precursor to a formal role.</td>
</tr>
<tr>
<td>Outsourced</td>
<td>CMCO role is performed by an external hire</td>
<td>Temporary hiring of an outside CMCO may be an option available to an enterprise that recognizes need for MC role but does not have expertise or capacity to staff from within. May also be a form used by an enterprise that is not convinced of value of CMCO, but wants to have trial implementation.</td>
</tr>
</tbody>
</table>
Accessioning is the formal process of officially accepting models (sets of models) into enterprise level model collection

- establish legal ownership, IP, verifies integrity, validates pedigree, etc.
- de-accessioning is equally important formal process
Responsibility
managing model acquisition activities

**ACQUISITION**

The act of acquiring a model through a formal arrangement with the model owner (e.g., through purchase, trade, or other business transaction).

**LOANS**

The act of temporarily loaning a model through an agreement whereby the model owner agrees to share the model with the model acquirer for a specified time and specified terms (e.g., terms of use, remuneration, etc.).
responsibility

valuation of models and digital artifacts

Are physical products and models of the product two separate things?
strategic role in future leadership of digital demonstrators

Museum curator has deep knowledge of collection, with responsibility for putting together purposeful special exhibits

Similar role – “chief model curator” has deep knowledge of model collection and its use for special purposes, for example:
  - selecting and composing models for a digital demonstration of new system capability in support of a competitive bid or market opportunity
enablers

model pedigree

A model pedigree contains all of the information about a model, its origins and use over time

PURPOSE
...enable the decision maker to determine the model’s status with respect to past achievements, theoretical and methodological state of the art, and the expert advice that went into its development

Gass & Joel (1980)

Pedigree has information not always included in engineering model documentation and metadata: model origin, originators and developers, development process used, assumptions and limitations, related expert knowledge, investment in model, etc.
enablers
reference map for model-centric vulnerabilities

Assess potential future vulnerabilities, plan interventions
Identify specific vulnerabilities to response to hazard
Change processes to mitigate or eliminate vulnerabilities
Organize/classify vulnerabilities into categories and types

Research Application Relevance
DoD Digital Engineering Strategy

... mitigate cyber risks and secure digital engineering environments against attacks from internal and external threats

... mitigate known vulnerabilities that present high risk to DoD networks and data

... mitigate risk posed by collaboration and access to vast amount of information in models

interim research findings

1. SERC’s initial investigation of model curation has indicated systems community will benefit from formal curation practices
2. Lack of access to models, mistrust of models, and perception of legitimacy of models are barriers to reuse and longevity that are potentially mitigated through model curation
3. Potential to adapt practices from other fields once model curation-specific needs are understood
4. Enablers for implementation have potential to further enhance practice: lexicon, pedigree standards, curation templates, etc.

Continuing SERC research will focus on three areas of inquiry ....
research question #1
What is the lifecycle model and what are the fundamental practices for model curation?

What useful lifecycle models exist in other fields of curation?

What relevant practices can be adopted/adapted for model curation?

Research approach: literature review, empirical knowledge gathering, technical exchanges
research question #2
What are the precursors, barriers and enablers for model curation?

Many questions to be explored through interaction with stakeholders

examples
• How are models presently managed and controlled?
• What roles/responsibilities exist within digital engineering programs
• How are models “certified”/evaluated for future use?

• What are the barriers to model throughout system lifespan?
• What issues impede model sharing between organizations?
• Can a model curator role benefit programs? Enterprises?

• What practices and templates can better enable model curation?
• How can technology help to make models discoverable?

Research approach: empirical knowledge gathering, technical exchanges, collaboration
research question #3

What innovations are emerging from other fields that may benefit model curation?

Leveraging new sciences/technologies: data science, visual analytics, machine learning, natural language processing, UX design, augmented intelligence, lightweight formal methods...

examples

• machine-learning assisted triage method to replace manual curation of biomedical knowledge, presently done by humans querying and reading articles (Lee et al., 2018)

• visualizations created from data, used in telling story of a library collection (Wissel & DeLuca, 2018)

• use of interactive visualization to provide curators with a means to analyze large-scale digital collections (Xu et al. 2014)

Research approach: literature review, empirical knowledge gathering
Interested in engaging in the research?

• Exemplars of emerging practice
• POCs interested in interim research activities
• Participants for “pathfinder” event

SERC PI Contact:
Dr. Donna H. Rhodes
Massachusetts Institute of Technology
rhodes@mit.edu

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