

Model Curation: Requisite Leadership and Practice in Digital Engineering Enterprises

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Conference on Systems Engineering Research

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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.

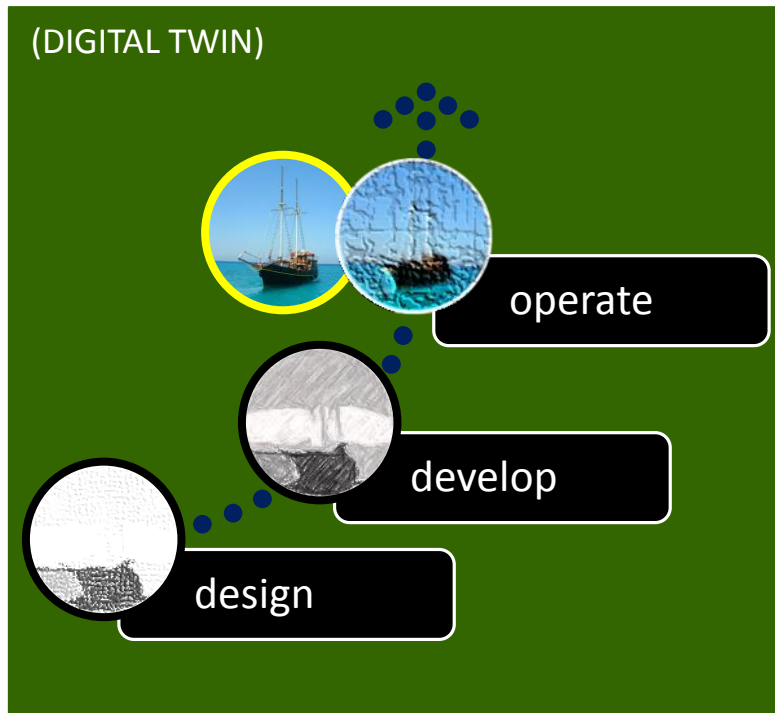
Rouse, 2015

Reymondet, L., Rhodes, D.H. & Ross, A.M. (2016). Considerations for Model Curation in Model-Centric Systems Engineering. 10th Annual IEEE Systems Conference, Orlando, FL.

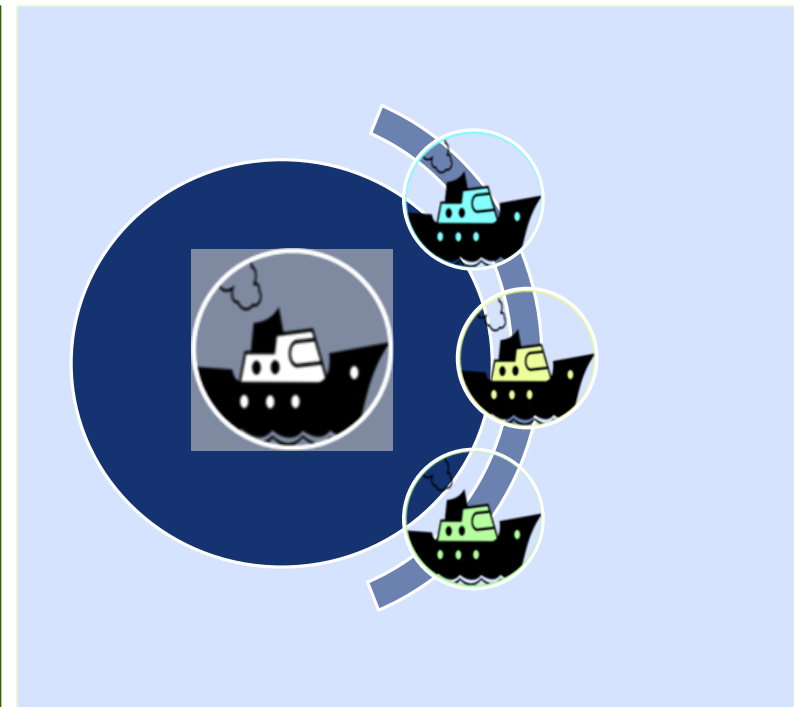
Rouse, W.B. (2015). *Modeling and Visualization of Complex Systems and Enterprises*. Hoboken, NJ: Wiley.

Rouse, W.B. & Bodner, D.A. (2013). Multi-Level Modeling of Complex Sociotechnical Systems. Rt-44 Phase 1 Report. Hoboken, NJ: SERC

THROUGH LIFESPAN



MODEL REUSE



Longer Duration

definition

*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:

Model Collection	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).
Model Collection Object	A model or model-related object that is a unique asset in the enterprise's collection. An object is assigned a unique identifier.
Model Composition	The process of composing models and model-related information that provides collective value beyond the individual models.
Model	The characteristic of an interrelated set of models that enables them to be combined in accordance with given modeling forms.

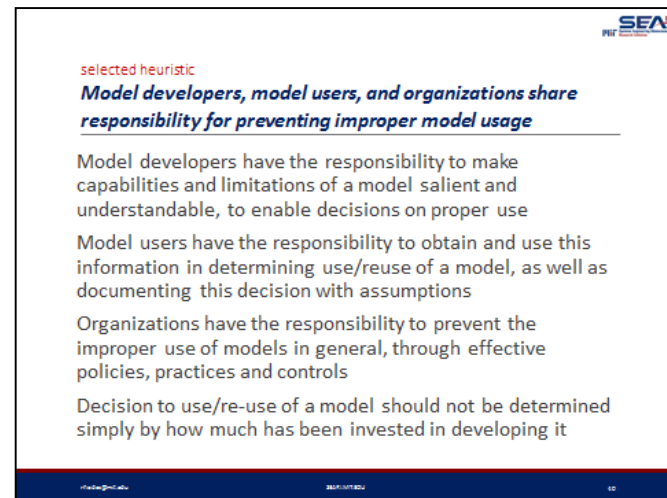
model curation role at program-level

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: *Program-Level Model Curator*

- maintains program-owned models
- plan/manage software version upgrades
- collaborates with CM and DM functions
- organizes training for program staff
- performs model trade-offs
- support model assessments and activities
-



selected heuristic
Model developers, model users, and organizations share responsibility for preventing improper model usage

Model developers have the responsibility to make capabilities and limitations of a model salient and understandable, to enable decisions on proper use

Model users have the responsibility to obtain and use this information in determining use/reuse of a model, as well as documenting this decision with assumptions

Organizations have the responsibility to prevent the improper use of models in general, through effective policies, practices and controls

Decision to use/re-use of a model should not be determined simply by how much has been invested in developing it

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a new enterprise-level leadership role

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



Image Credit: DNV GL Annual Report, 2015

initial investigation of enterprise leadership organizational forms

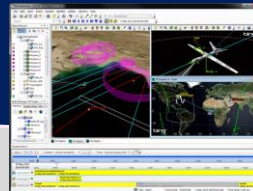
Form	Description	Chief Model Curation Office (CMCO) Organizational Form – under what conditions
<i>Centralized – Top Tier</i>	CMCO is a top tier exec reporting directly to CEO	High performing model-centric engineering enterprise or enterprise that has a very aggressive goal to become one. Culture has fully embraced model-centric engineering across entire enterprise, and enterprise believes model leadership is key to competitive advantage and innovation.
<i>Centralized – Dotted Line</i>	CMCO has “dotted line” reporting CEO	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.
<i>Franchised</i>	Enterprise units have CMCOs, with common policies	For very large enterprises with top-tier CMCO. In a franchise model, each unit has its top executive, confirming to the enterprise CMCO.
<i>Collaborative</i>	Virtual CMCO role via collaborative committee	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.
<i>Dual Hat</i>	CMCO is one of two roles played by an executive	Instance where this may be a preferred form is an enterprise comprised of many newer acquisitions that have strong heritage culture and processes. An enterprise that is working with multiple approaches; not ready to appoint single individual but enables enterprise to allocate specific curation responsibilities to an existing leader (CIO, CTO, CDO).
<i>Delegated</i>	CMCO tasks delegated to one or more individuals	Similar to “dual hat” but role is not specifically delegated; responsibilities are delegated as add-ons to an existing role, or to the responsibilities of a standing committee. This implementation is weaker than dual hat, but does acknowledge these MC responsibilities, as a precursor to a formal role.
<i>Outsourced</i>	CMCO role is performed by an external hire	Temporary hiring of an outside CMCO may be only 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.

responsibility model accessioning

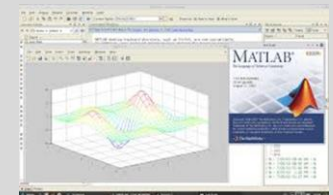
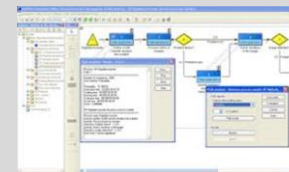
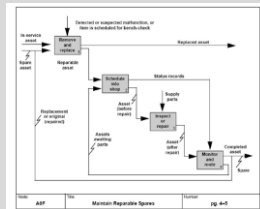
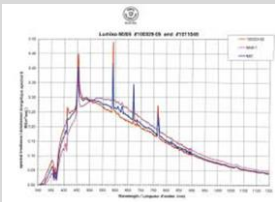
Accessioning is the formal process of officially accepting models (sets of models) into enterprise level model collection

- establish legal ownership, IP, verifies integrity, validates pedigree, etc.
- de-accessioning is equally important formal process

enterprise collection



models



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).

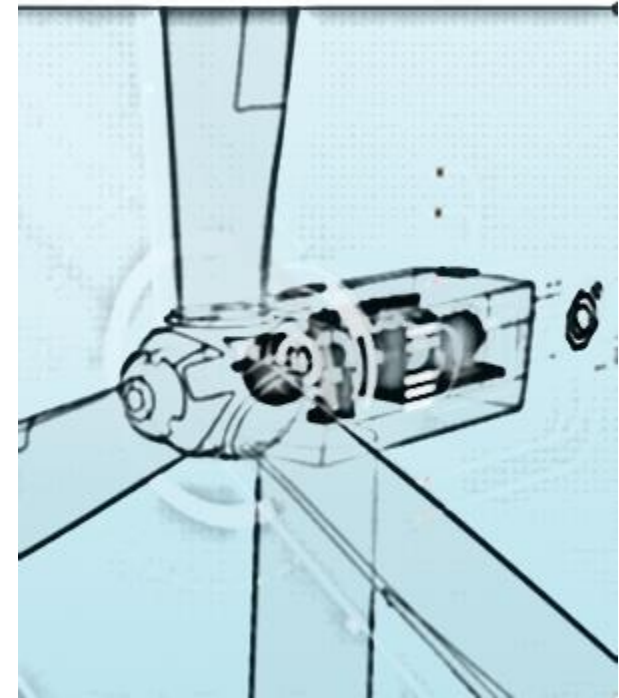
LOANS

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?*



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.



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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

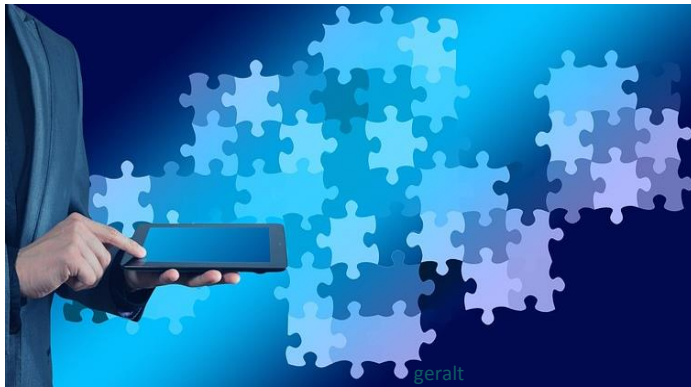


Image credit: <https://www.globalrailwayreview.com/article/72072/digital-twins-it-ot/>

interim research findings

1. 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.

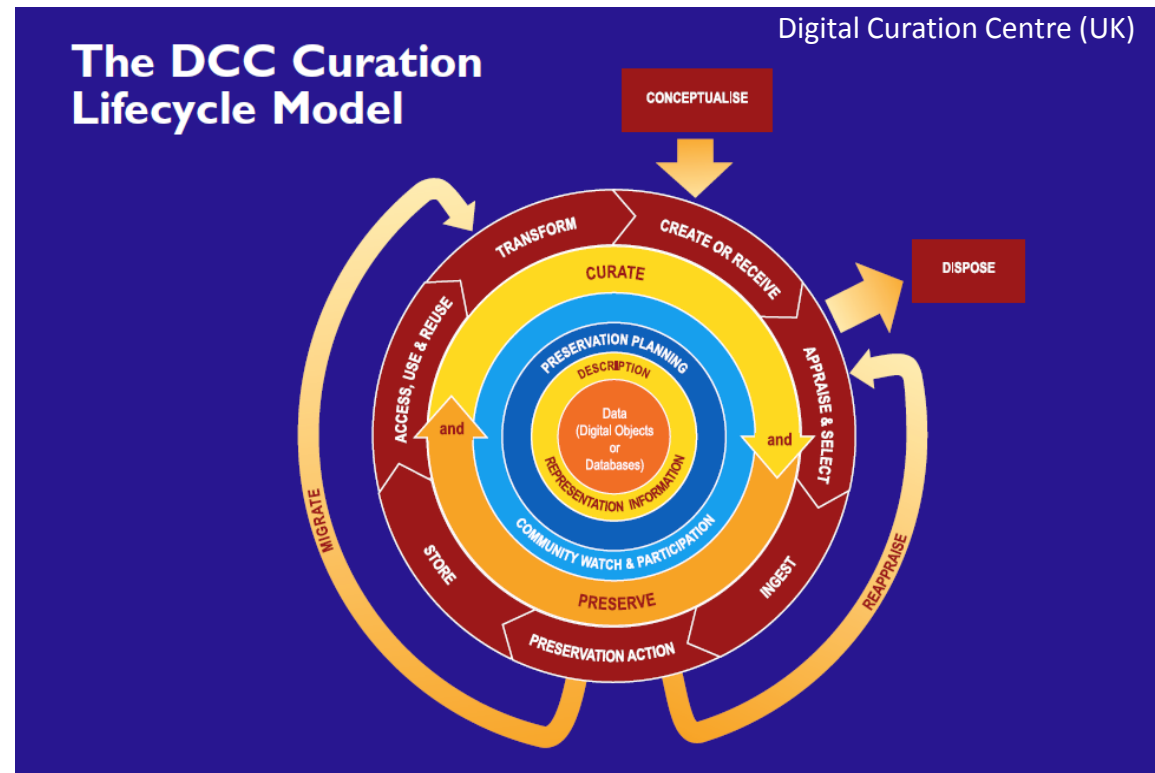
Continuing SERC research will focus on three areas of inquiry

research question

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

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

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

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