# Model Curation: Requisite Leadership and Practice in Digital Engineering Enterprises
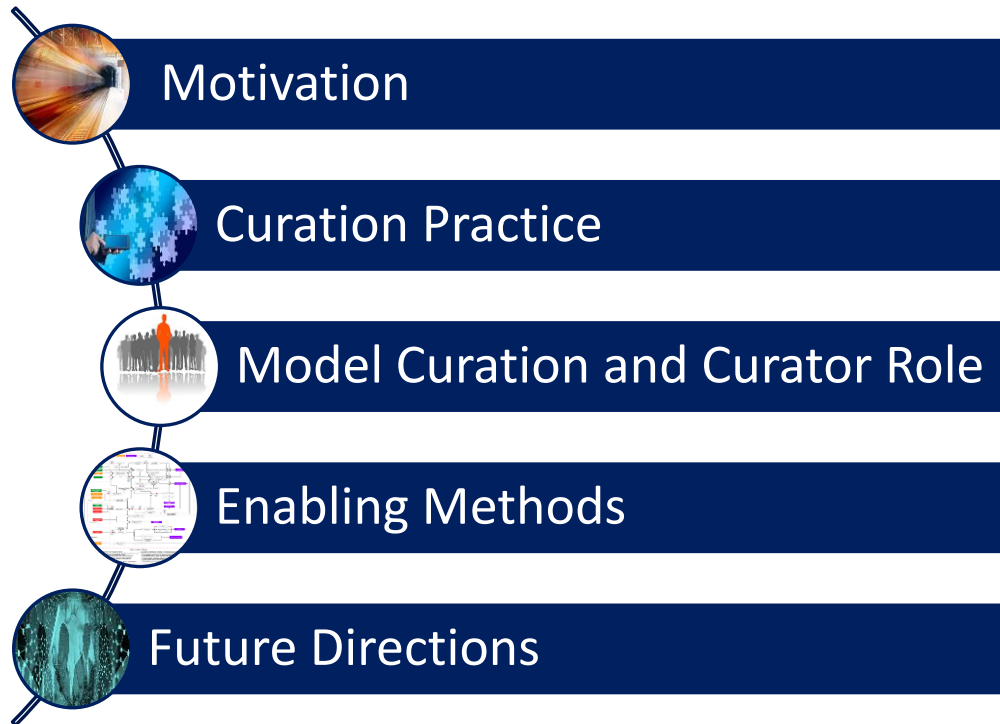
### 17th Annual Conference on Systems Engineering Research (CSER)

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SYSTEMS
ENGINEERING
RESEARCH CENTER

SEA RI
MiT Systems Engineering Advancement
Research Initiative

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

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.
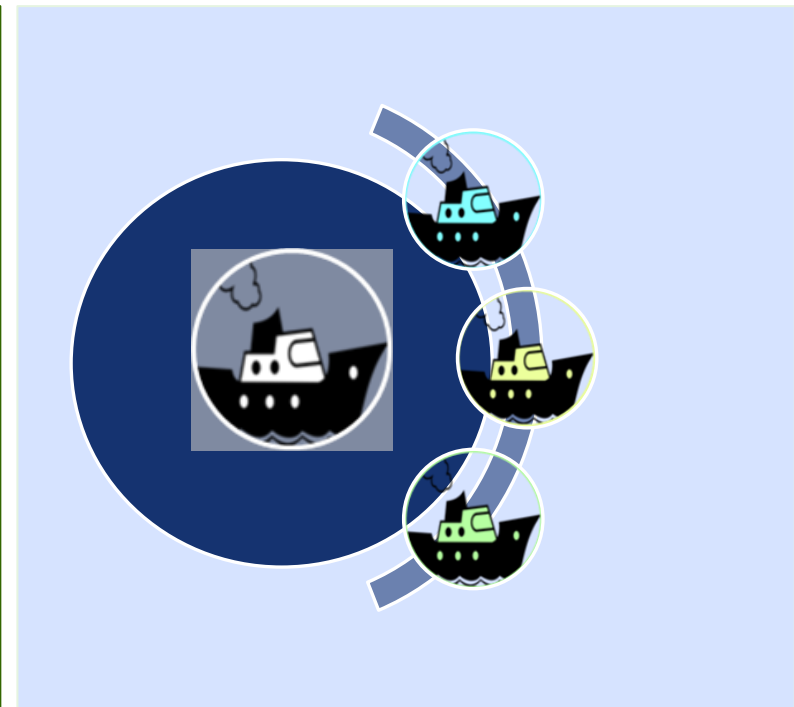Rouse, W.B. (2015). *Modeling and Visualization of Complex Systems and Enterprises*. Hoboken, NJ: Wiley.
Rouse, W.B. & Bodner, D.A. (2013). Multi-Level Modeling of Complex Sociotechnical Systems. Rt-44 Phase 1 Report. Hoboken, NJ: SERC

# THROUGH LIFESPAN

# MODEL REUSE

(DIGITAL TWIN)

operate

develop

design
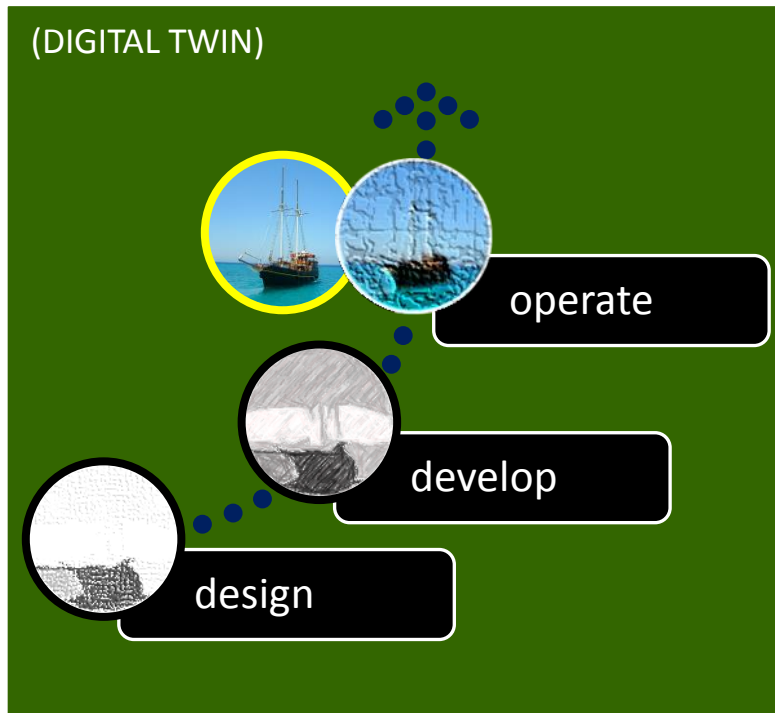
*Longer Duration*

# 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:



| | |
|---|---|
| ...er Collection | The collection of model-based assets that is possessed by... including those developed by the enterprise, acquired by the ent... 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. |
| ...al | The characteristic of an interrelated set of models that enable... be combined in accordance with given modeling for... |

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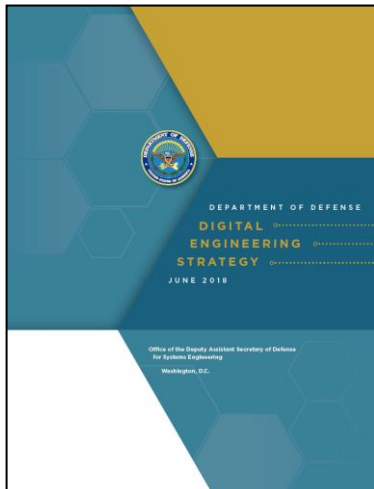
**Enterprise model curator role aligned with the goals of the DoD Digital Engineering Strategy**

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

| Form | Description | Chief Model Curation Office (CMCO) Organizational Form – under what conditions |
|---|---|---|
| Centralized – Top Tier | 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. |
| Centralized – Dotted Line | 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. |
| Franchised | Enterprise units have CMCOs, with common policies | For very large enterprises with top-tier CMCO. In a franchised [...] its top executive, conforming to enterprise defined policy and role. |
| Collaborative | Virtual CMCO role via collaborative committee | Enterprise does not wish to appoint a CMCO [...] appointed collaborative committee is "virtual CMCO" as a strategy-setting and oversight body. May be preferred in enterprise comprised [...] acquisitions [...] heritage culture and processes. |
| Dual Hat | CMCO is one of two roles played by an executive | An enterprise that is working to [...] approaches; not ready to appoint [...] to perform, enables enterprise to allocate specific curation responsibilities to an existing leader (CIO, CTO, CDO). |
| Delegated | 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 as MC responsibilities, as a precursor to a formal role. |
| Outsourced | 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. |

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.

Instance where this may be a preferred form is an enterprise comprised of many newer acquisitions that have strong heritage culture and processes.
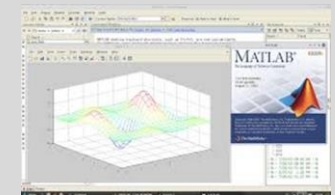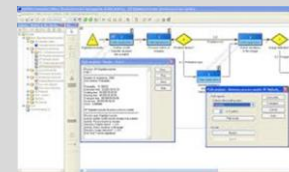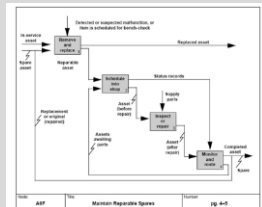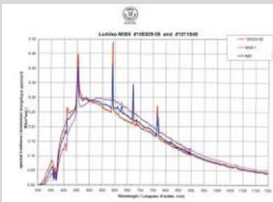
# model accessioning

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
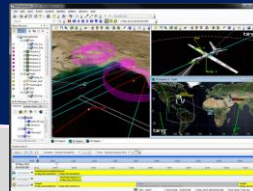
models

## 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).
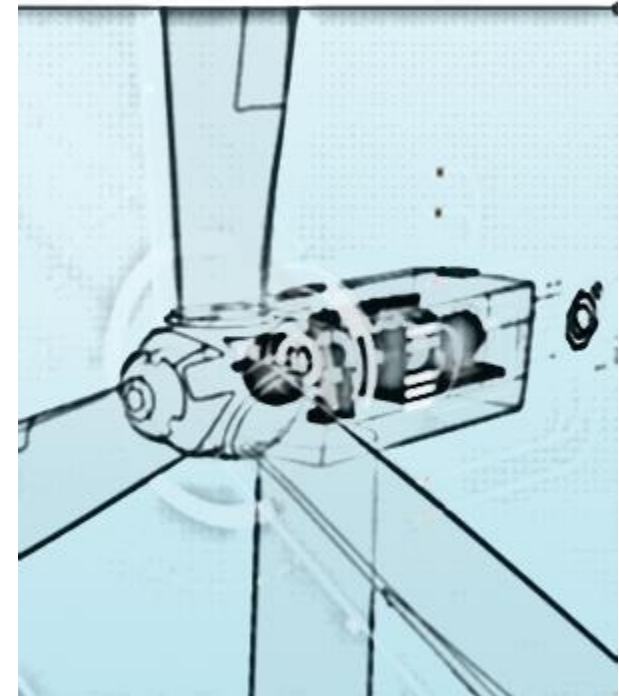
**LOANS**

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.).

# 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:

o selecting and composing models for a digital demonstration of new system capability in support of a competitive bid or market opportunity
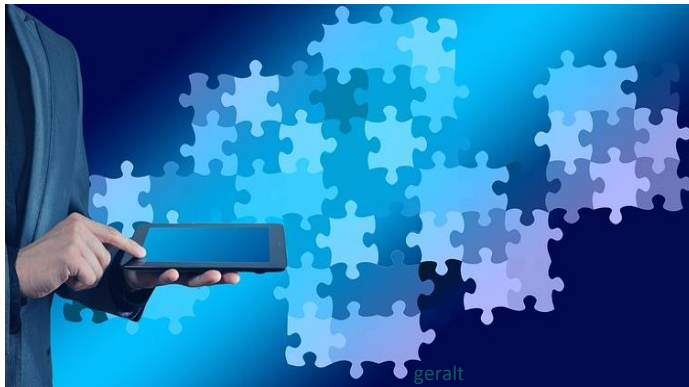


geralt

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

# 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.

# reference map for model-centric vulnerabilities

ACQUISITION RESEARCH PROGRAM
GRADUATE SCHOOL OF BUSINESS & PUBLIC POLICY
NAVAL POSTGRADUATE SCHOOL

Reid & Rhodes, 2018

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*
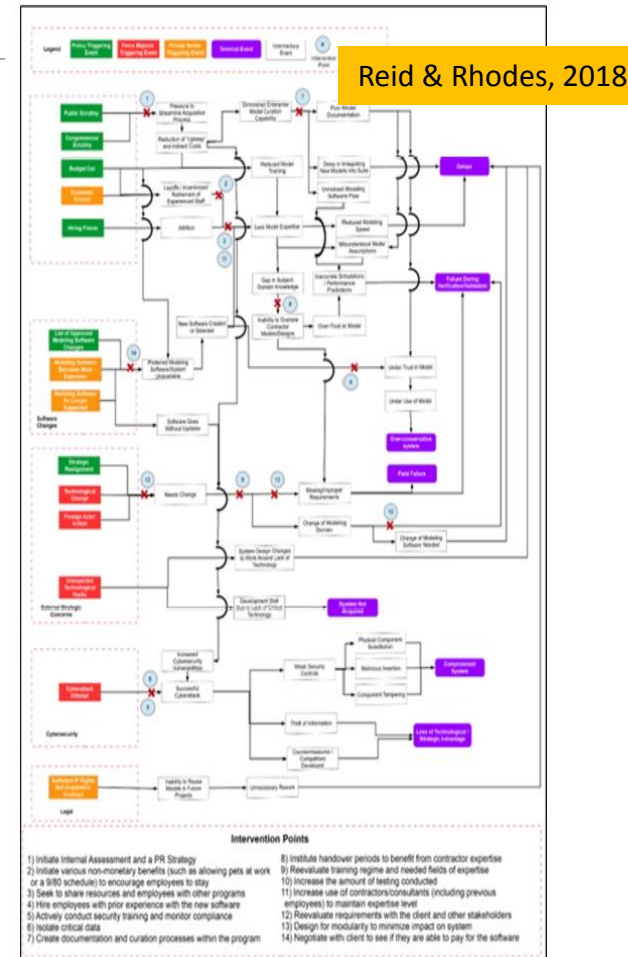
https://www.acq.osd.mil/se/docs/2018-DES.pdf



Figure 5. Reference CEM for Model-Centric Vulnerabilities (Preliminary)

# 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.
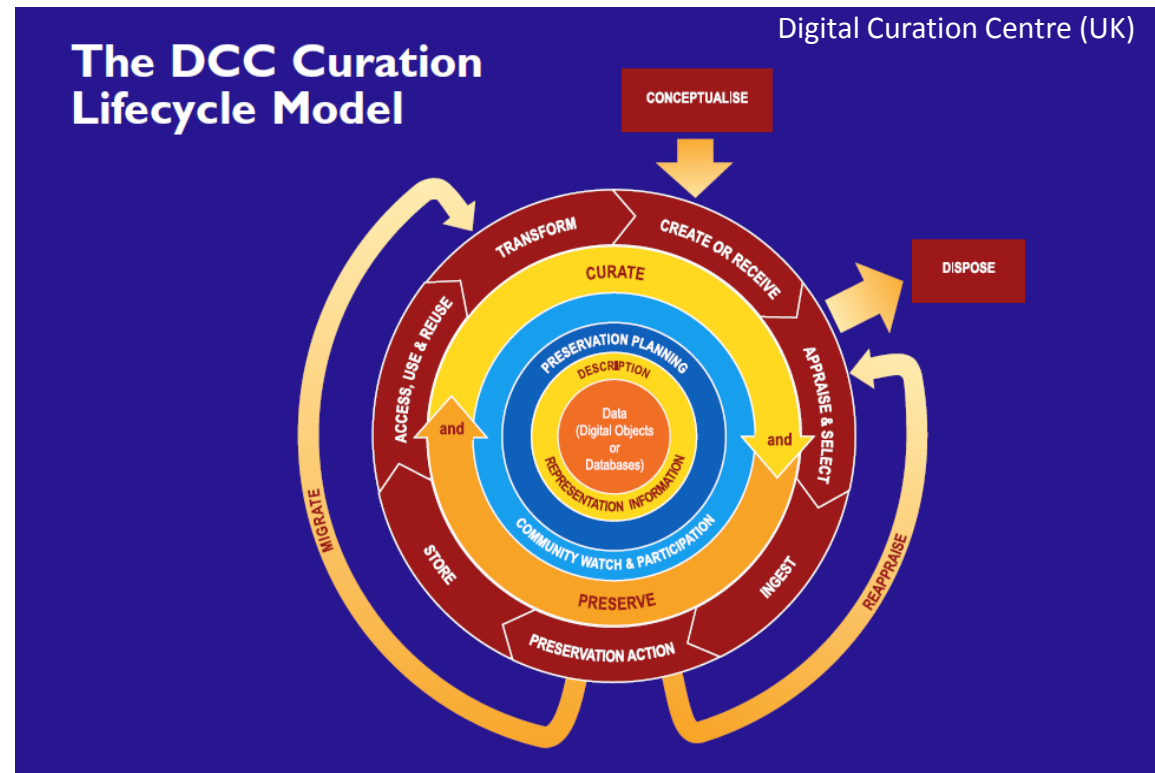
Continuing SERC research will focus on three areas of inquiry ….

# *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?



Digital Curation Centre (UK)

**The DCC Curation Lifecycle Model**

**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

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