Challenges of Preserving Digital Twins

I Trust AI International Symposium
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I Trust AI

I Trust AI aims to:

- Generate new knowledge on the uses of AI, such as Machine Learning (ML), on public records
- Improve upon existing tools and create new ML tools that will address:
  - archival needs, such as machine translation, image recognition and description, optical character recognition (OCR) and handwritten text recognition, text summarization and classification, and text style transfer for language civilization (e.g., removal of bias, hate, and sexism).
  - The tools developed will be tailored to, tested for, and deployable by the records and archives community
- **Produce best practices, standards, and guidelines for applying ML tools across an entire problem space,** bringing archival knowledge and practice to bear on problems such as bias in ML, explainable artificial intelligence (XAI), and image description
- **Enrich research** and lead to **knowledge co-creation in several disciplines,** including archival science, records management, AI, cybersecurity, information science, law, and ethics, through knowledge exchange and uptake between scholars and practitioners within and among those discipline
- Train a substantial cohort of students -- future scholars and professionals -- who will bring their enhanced knowledge to the institutions, organizations, communities, and governments they will serve, and to the archives and records community as a whole

I Trust AI Research Objectives:

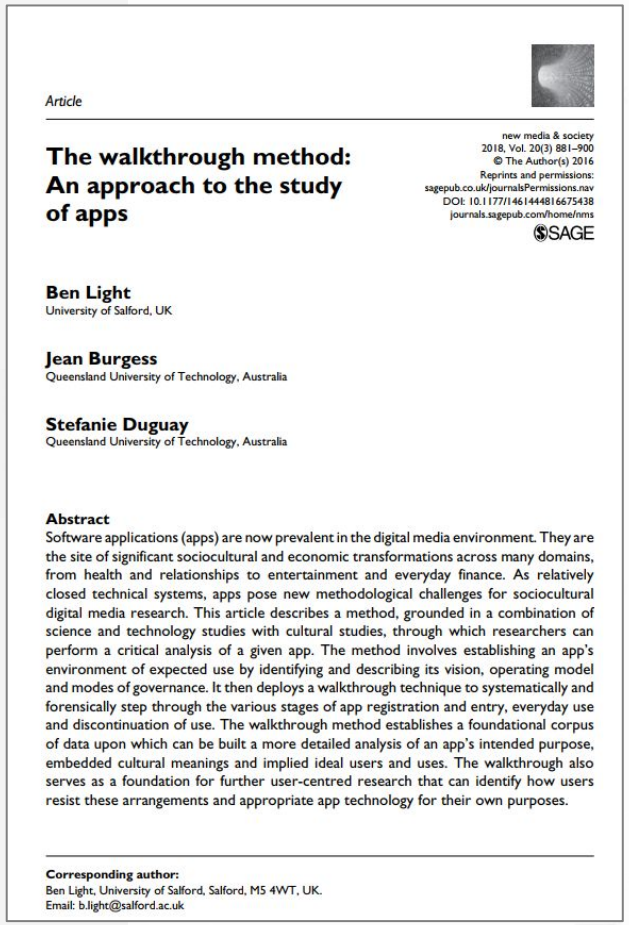
1. Identify specific AI technologies that can address critical records and archives challenges
2. Determine the risks and benefits of using AI technologies on records and archives
3. **Establish how archival concepts and principles can inform the development of responsible AI**
4. **Validate outcomes from Objective 3 through case studies and demonstrations**

Framing & Methodology

Critical Data Studies

- Data do not exist independently of the ideas, instruments, practices, contexts and knowledges used to generate, process and analyze them
- Application of social theory to the study of data and technology
- Conceptualizing Data & Technological Systems

Walkthrough Method



Article

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SAGE

The walkthrough method: An approach to the study of apps

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Abstract

Software applications (apps) are now prevalent in the digital media environment. They are the site of significant sociocultural and economic transformations across many domains, from health and relationships to entertainment and everyday finance. As relatively closed technical systems, apps pose new methodological challenges for sociocultural digital media research. This article describes a method, grounded in a combination of science and technology studies with cultural studies, through which researchers can perform a critical analysis of a given app. The method involves establishing an app's environment of expected use by identifying and describing its vision, operating model and modes of governance. It then deploys a walkthrough technique to systematically and forensically step through the various stages of app registration and entry, everyday use and discontinuation of use. The walkthrough method establishes a foundational corpus of data upon which can be built a more detailed analysis of an app's intended purpose, embedded cultural meanings and implied ideal users and uses. The walkthrough also serves as a foundation for further user-centred research that can identify how users resist these arrangements and appropriate app technology for their own purposes.

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Engage directly w/ a technological system to examine its technological mechanism & embedded cultural references

1. Environment of expected use
   - Vision, operating model, modes of governance
2. Walkthrough technique
   - Systematically & forensically step through the stages of use
   - Build a corpus of knowledge
3. Analysis
   - intended purpose, embedded cultural meaning, implied ideal use & users
   - How users resist intended purposes & use the technological system differently

Social & Technological Data Assemblage

Social and technological open data assemblage

System/process
performs a task

Reception/Operation (user/usage) smart city, precision agriculture, in a data brokerage firm, as part enterprise architectures.

Interface (government website, application, dashboards, maps)

Code/algorithms
(software, open source, proprietary source, machine learning, artificial intelligence, algorithm)

Portal (Ckan, Tableau, Socrata, Federal Geographic Platform,, archives, repositories)

Data(base) (structured, unstructured, semi-structured, object oriented, big data, real-time data, satellite data, formats, distributed & centralized, BIMs, traffic management systems etc.)

Classification (ontologies, semantics, NAICS, metadata, Linked Data)

Code Platform
(operating system) (Prime2, Oracle, Prism, IBM, Siemens, Cisco included open and closed source code, APIs, LBS, GPS, etc.)

Material Platform
Infrastructure, hardware, cloud, stacks, data centres, sensors, internet of things (IoT), broadband, networks.

Context
frames the system/task

Systems of Thought (open government, data as a discursive regime, & new managerialism, evidence informed decision making)

Forms of Knowledge (Open Data Charter, indexes, playbooks, roadmaps, digital strategies, barometer)

Practices (hackathons, inventories, citizen & resident engagement, open with purpose)

Finance (budgets, ROI, business models)

Political Economies (proactive disclosure, business registries, spending, procurement, open by default)

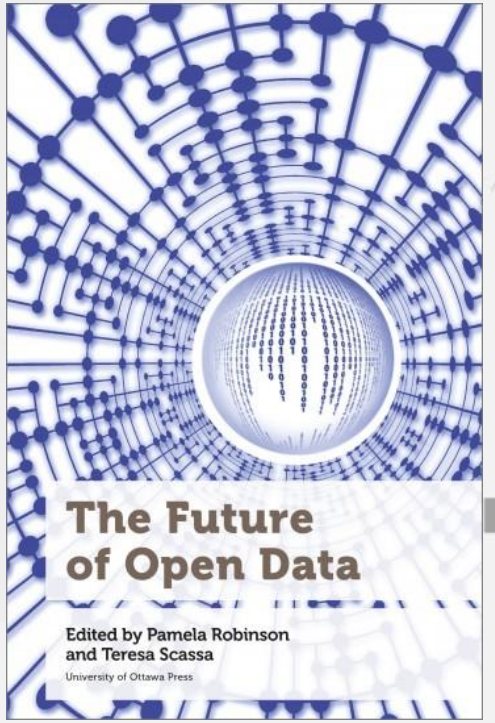
Governmentalities & Legalities (standards, licences, copyright, PIPEDA, EU-GDPR, OCAP Principles, ITK National Inuit Strategy on Research)

Organizations & Institutions (National, provincial/territorial, country and city governments, TBSC, OKF, OGP, consultancies, First Nation Treaties, First Nation, Metis & Inuit communities)

Subjectivities & communities (scientists, policy makers, smart cities, private sector, special interest - GODAN & IATI, users, information management and IT, CEOs/CDOs, First Nation, Metis & Inuit peoples)

Marketplace (ingested by data brokers, re-used and combined with private data, geodemographics, data analytics, grants, procurement)

Places (government offices, cities, conferences, geodata)



Lauriault, T. P. Looking Back Toward A "Smarter" Open Data Future

Methodology

InterPARES 2 Project
International Research on Permanent Authentic Records in Electronic Systems

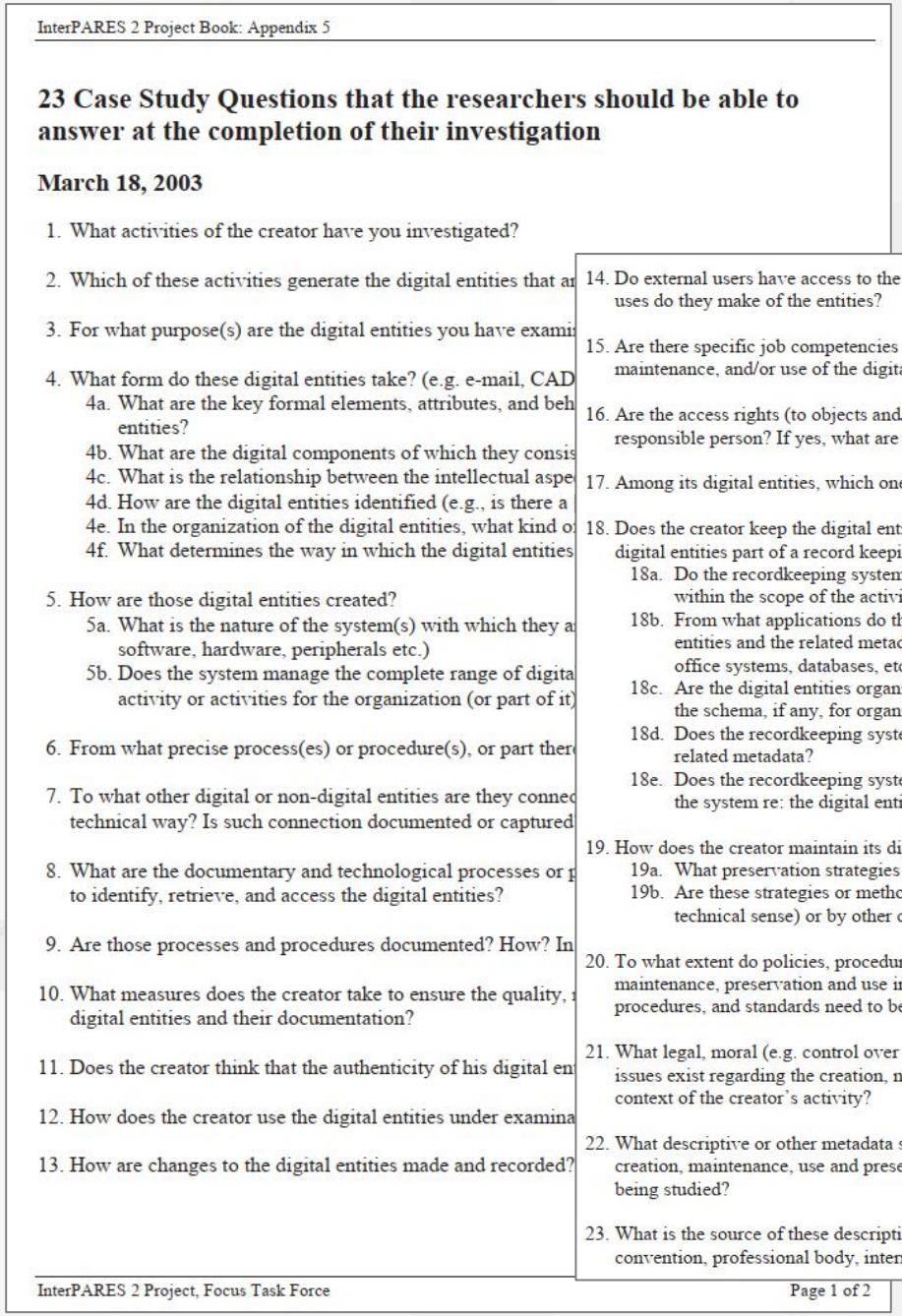
International Research on Permanent Authentic Records in Electronic Systems (InterPARES) 2: Experiential, Interactive and Dynamic Records

APPENDIX 5

23 Case Study Questions that the researchers should be able to answer at the completion of their investigation

APPENDIX 8

InterPARES 2 Reporting Framework



InterPARES 2 Project Book: Appendix 5

23 Case Study Questions that the researchers should be able to answer at the completion of their investigation

March 18, 2003

1. What activities of the creator have you investigated?
2. Which of these activities generate the digital entities that ar
3. For what purpose(s) are the digital entities you have exami
4. What form do these digital entities take? (e.g. e-mail, CAD
   - 4a. What are the key formal elements, attributes, and beh entities?
   - 4b. What are the digital components of which they consis
   - 4c. What is the relationship between the intellectual aspe
   - 4d. How are the digital entities identified (e.g., is there a
   - 4e. In the organization of the digital entities, what kind o
   - 4f. What determines the way in which the digital entities
5. How are those digital entities created?
   - 5a. What is the nature of the system(s) with which they a software, hardware, peripherals etc.)
   - 5b. Does the system manage the complete range of digita activity or activities for the organization (or part of it)
6. From what precise process(es) or procedure(s), or part ther
7. To what other digital or non-digital entities are they connec technical way? Is such connection documented or captured
8. What are the documentary and technological processes or p to identify, retrieve, and access the digital entities?
9. Are those processes and procedures documented? How? In
10. What measures does the creator take to ensure the quality, digital entities and their documentation?
11. Does the creator think that the authenticity of his digital en
12. How does the creator use the digital entities under examina
13. How are changes to the digital entities made and recorded?
14. Do external users have access to the digital entities in question? If so, how, and what kind of uses do they make of the entities?
15. Are there specific job competencies (or responsibilities) with respect to the creation, maintenance, and/or use of the digital entities? If yes, what are they?
16. Are the access rights (to objects and/or systems) connected to the job competence of the responsible person? If yes, what are they?
17. Among its digital entities, which ones does the creator consider to be records and why?
18. Does the creator keep the digital entities that are currently being examined? That is, are these digital entities part of a record keeping system? If so, what are its features?
    - 18a. Do the recordkeeping system(s) (or processes) routinely capture all digital entities within the scope of the activity it covers?
    - 18b. From what applications do the recordkeeping system(s) inherit or capture the digital entities and the related metadata (e.g. email, tracking systems, workflow systems, office systems, databases, etc.)?
    - 18c. Are the digital entities organized in a way that reflects the creation processes? What is the schema, if any, for organizing the digital entities?
    - 18d. Does the recordkeeping system provide ready access to all relevant digital entities and related metadata?
    - 18e. Does the recordkeeping system document all actions/transactions that take place in the system re: the digital entities? If so, what are the metadata captured?
19. How does the creator maintain its digital entities through technological change?
    - 19a. What preservation strategies and/or methods are implemented and how?
    - 19b. Are these strategies or methods determined by the type of digital entities (in a technical sense) or by other criteria? If the latter, what criteria?
20. To what extent do policies, procedures, and standards currently control records creation, maintenance, preservation and use in the context of the creator's activity? Do these policies, procedures, and standards need to be modified or augmented?
21. What legal, moral (e.g. control over artistic expression) or ethical obligations, concerns or issues exist regarding the creation, maintenance, preservation and use of the records in the context of the creator's activity?
22. What descriptive or other metadata schema or standards are currently being used in the creation, maintenance, use and preservation of the recordkeeping system or environment being studied?
23. What is the source of these descriptive or other metadata schema or standards (institutional convention, professional body, international standard, individual practice, etc.?)

InterPARES 2 Project, Focus Task Force — Page 1 of 2

Archive a Digital Twin

- Test the preservation of Carleton's Digital Twin
- Carleton University Archives

Digital Twin

A digital twin is

- An ecosystem of multi-dimensional and interoperable subsystems of
  - things in the real world, natural & human made
  - a digital replica of those things
  - a system that communicates between the digital and the real-world things
  - and the people and institutions that govern, contribute to, use and share it
- Primarily w/in architecture, engineering, construction, and operations (AECO)

Digital Twin Application Areas

- **Physically large projects**
  - **Buildings,** bridges & complex structures bound by strict rules of engineering.
- **Mechanically complex projects**
  - Jet turbines, automobiles and aircraft to help improve efficiency w/in complicated machinery & mammoth engines.
- **Power equipment**
  - This includes the **mechanisms for generating power and transmitting it.**
- **Manufacturing projects**
  - Help streamline process efficiency, as in industrial environments w/ co-functioning machine systems.

Digital Twin

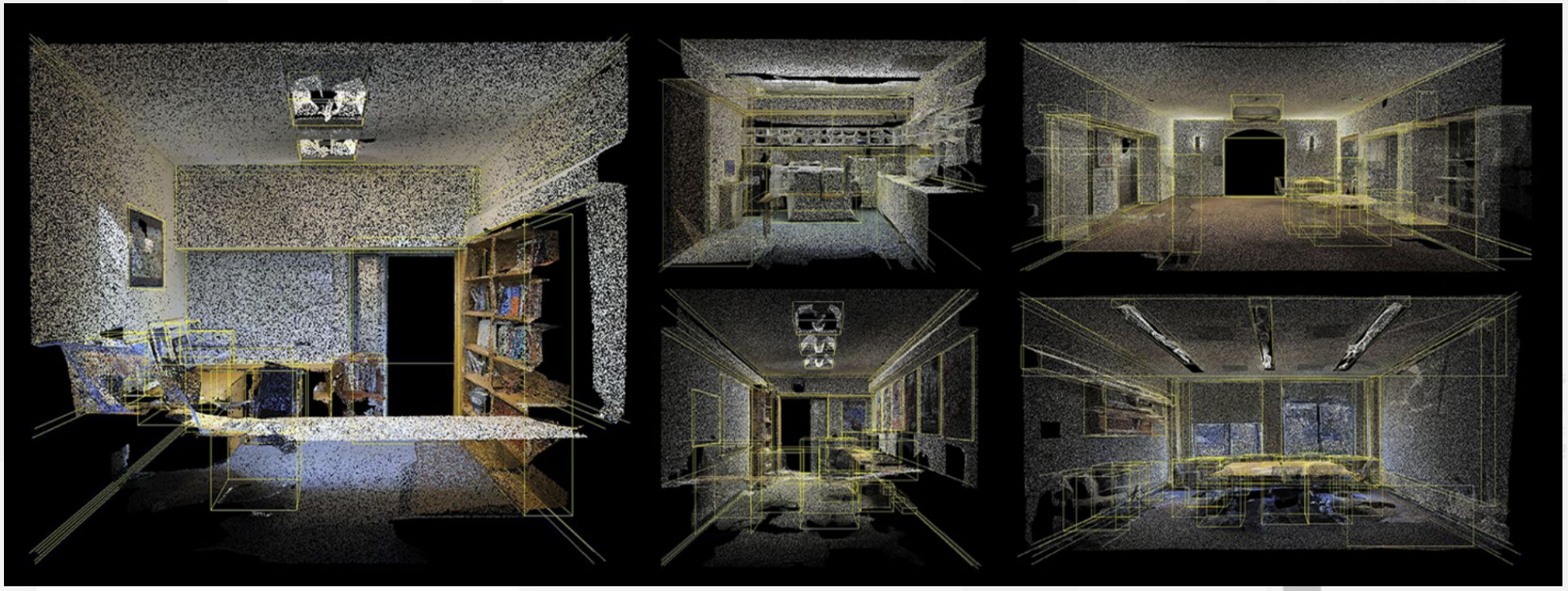
Carleton Immersive Media Studio
ESRI

Controlling a playable character a
between development scenarios A
experience. Photo Credit: Natalie

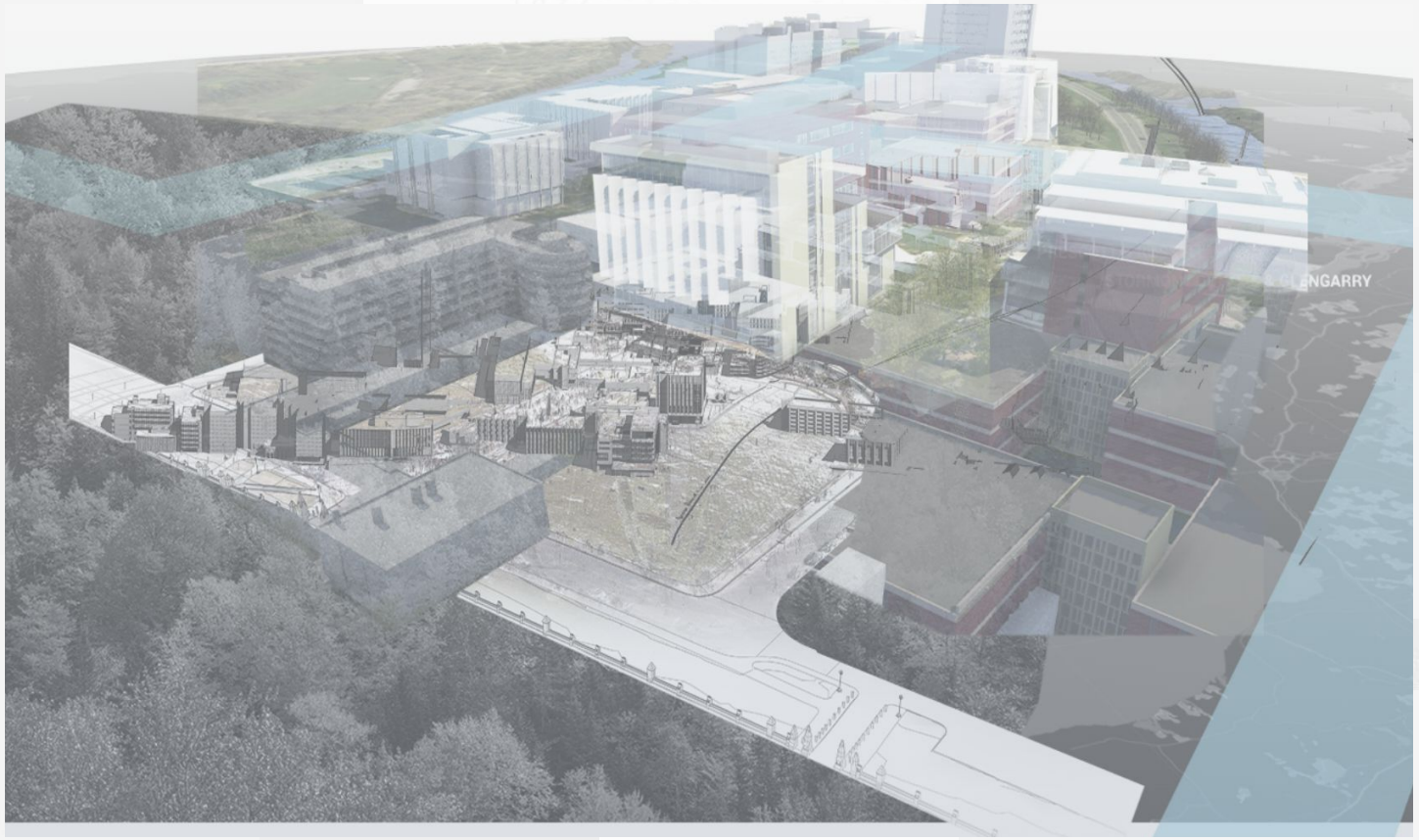
sville to better visualize the
io B shown above.) Photo

AI & Digital Twins

"BIM model to semantically segment laser scan point clouds. These segmented point clouds could then in turn be used to train an AI point cloud classification algorithm. CIMS also worked to manually segment a data set of gothic style 'high heritage' value rooms to assist the training of an AI point cloud segmentation algorithm, which commonly has troubles with the variations present in heritage spaces".



CS04 - Digital Twin



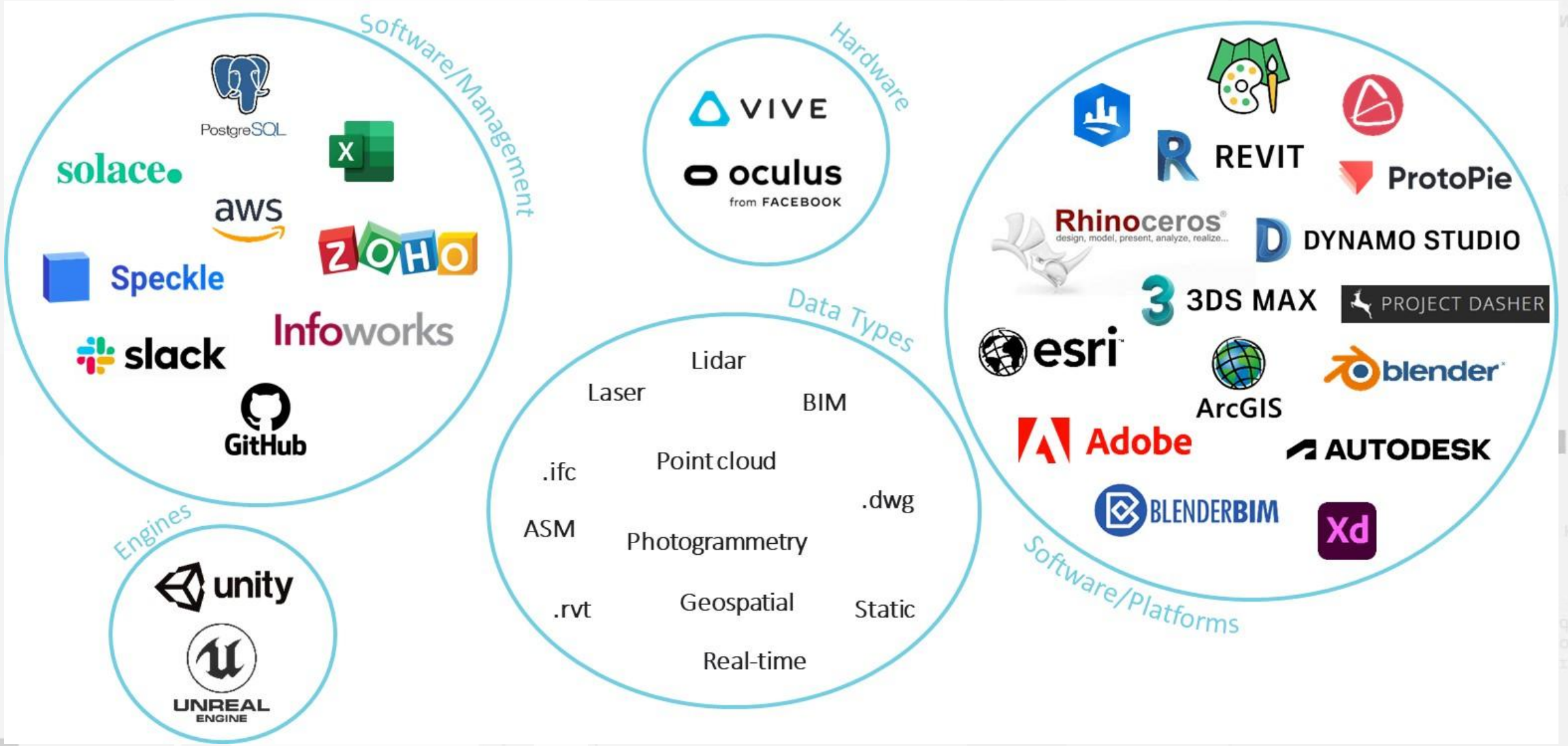
Imagining Canada’s Digital Twin

- Sustain Digital Campus project conducted experimentation in 4 test buildings at Carleton U.
- 8 BIM buildings at Carleton
- DT ecosystem of technologies & data allows Architecture, Engineering, Construction, and Operations (AECO) professionals analyze real-time data and visualize the modeling and analysis results into their actual designs, improving the overall process and to manage these assets.

CU04 – Digital Twin Objectives

- A case study to understand **how a digital twin is used and created so that it can be preserved**
- **Test the preservation of the Carleton University Digital Twin** created as part of the digital campus work at the Carleton Immersive Media Studio (CIMS) and the Sustain Project
- By doing so, **is it possible to use AI to automate the preservation of digital twins and related technologies**
- How can DT **AI/ML + IoT be preserved**

Sample of CIMS DT Data & Technology

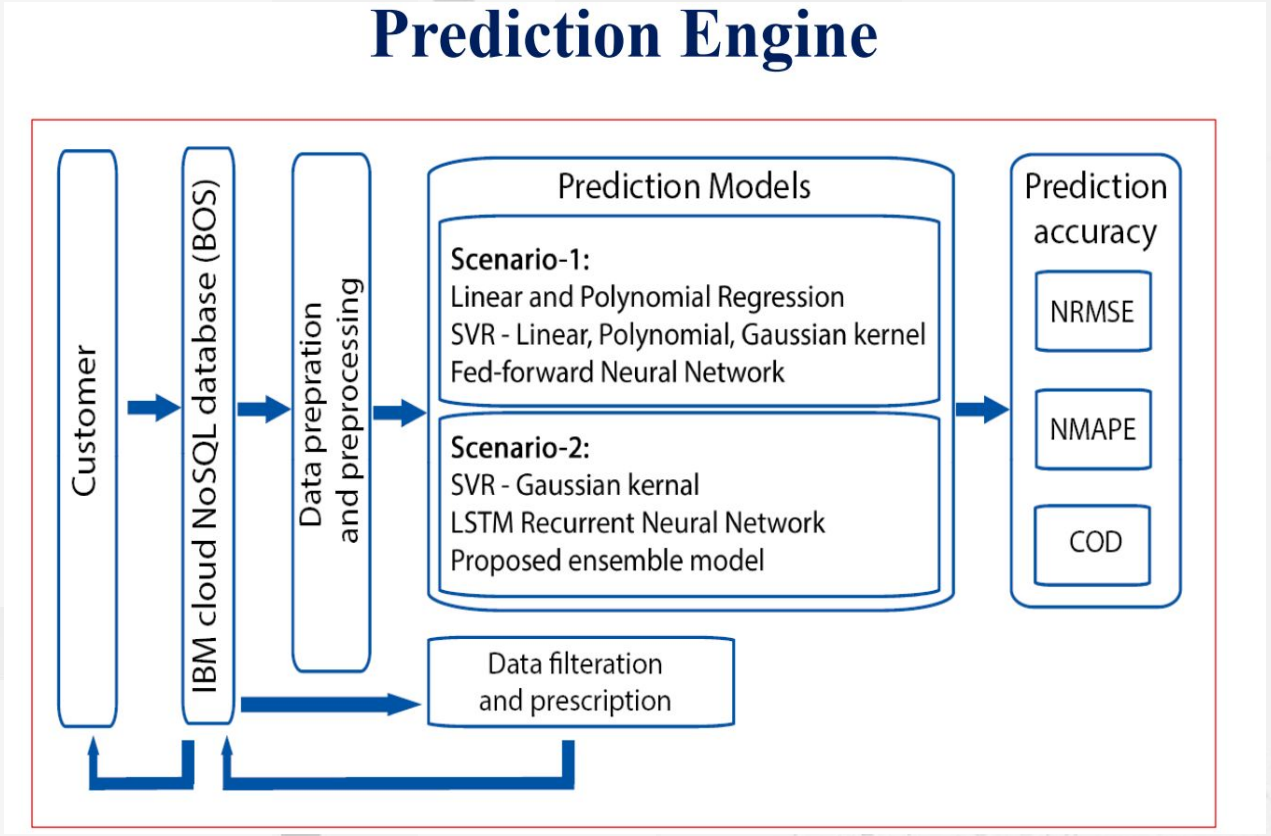


CS04 – Digital Twin

1. Provides critical records and archival challenges in terms of the use and creation of complex records – **BIM, ASM, Digital Twins, VR and AI**
2. Involves and **ecosystem of data, real-time systems, AI/ML, IoT, building information systems (BIM), asset management systems (AMS), LIDAR, VR, simulations and techniques, technologies, and data** of importance to fields in architecture, urbanism, planning, construction and engineering.
3. Archival concepts of authenticity, reliability, and accuracy, and others will be identified as research progresses.

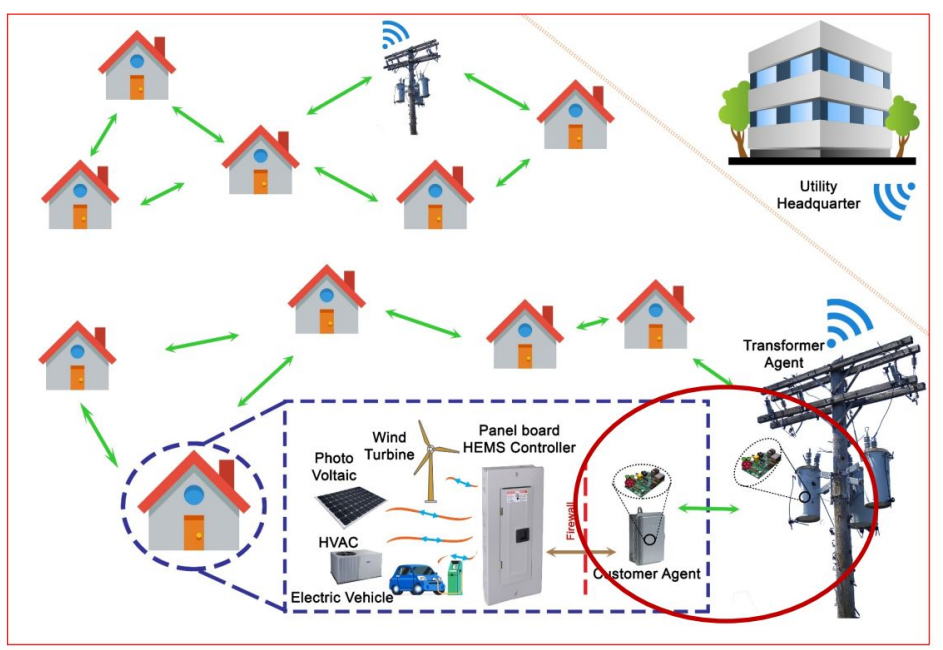
CS03 - Smart Grid Data Communication and Analytics

- Smart grids monitor energy consumption and manage production and distribution **using a variety of AI/ML and algorithms to predict consumption to manage the grid at power generation but also at the individual household with billing and consumption information**
- Common a central element in most smart city strategies, **smart grids must address archival and record keeping concerns in order to support accountability of decision-makers and transparency to clients/consumers**



Sensor Systems and The Internet of Things LAB

CS03 - Smart Grid Case Study



- The Sensor Systems and The Internet of Things Lab at Carleton University conducts research with the **Ontario Smart Grid that uses AI/ML in its IoT System**
- To **inform how archival concepts and principles can influence the development of responsible AI**; and will enable **outcomes to be validated**, thus directly addressing objectives:
- Will be a source of information for other studies in connection with explainable AI, creation, use, retention, and preservation.
- Has important implications for utilities worldwide, for instance for The Ontario Smart Grid System

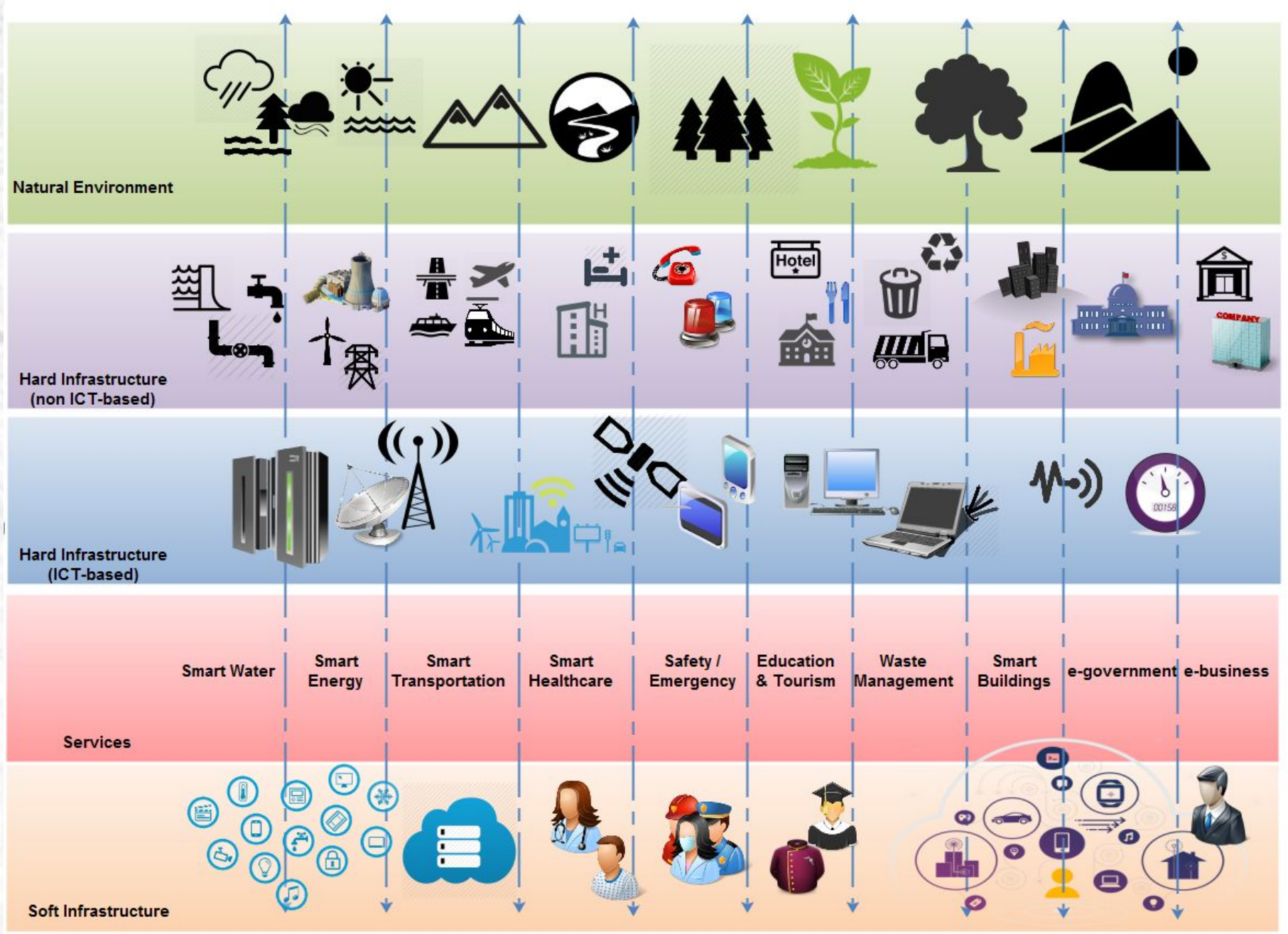
CS03 – Smart Grid Objectives

1. The documentation generated in the implementation of a substantial system affecting millions daily by a business of which a democratically elected government and private/public utilities is the majority shareholder, **will provide critical insights into the accountability of a major utility.**
2. Likewise, **the findings will clarify the degree to which ML implementations of this scope and complexity are "explainable" to decision-makers and consumers.**
3. **Good practices identified can be communicated to other jurisdictions and utilities considering similar ML-based enhancements.**
4. To conduct an **Analysis of the juridical, provenancial, and procedural contexts of ML-based improvements.**

CS Research have implications for Smart Cities

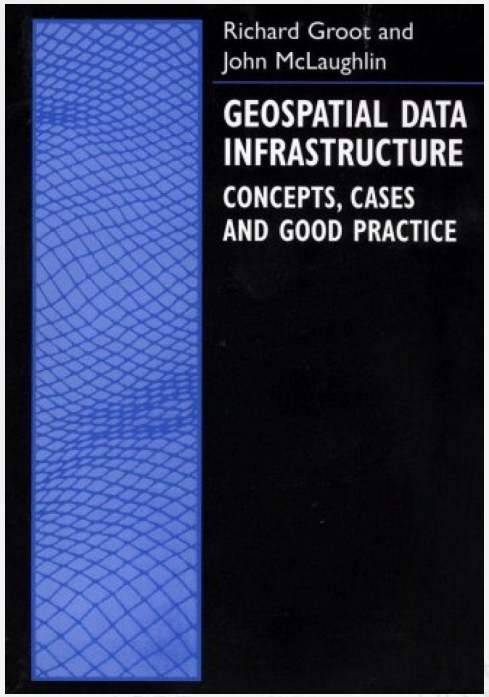
- technologically instrumented & networked w/ systems that are interlinked & integrated, where vast troves of big urban data are being generated by sensors & administrative processes used to manage & control urban life in real-time (Kitchin, 2018).
- where administrators and elected officials invest in smart city technologies & data analytical systems to inform how to innovatively, economically, efficiently & objectively run & manage the city.
- The focus is most often to quantify & manage infrastructure, mobility, business & online government services.

Smart City



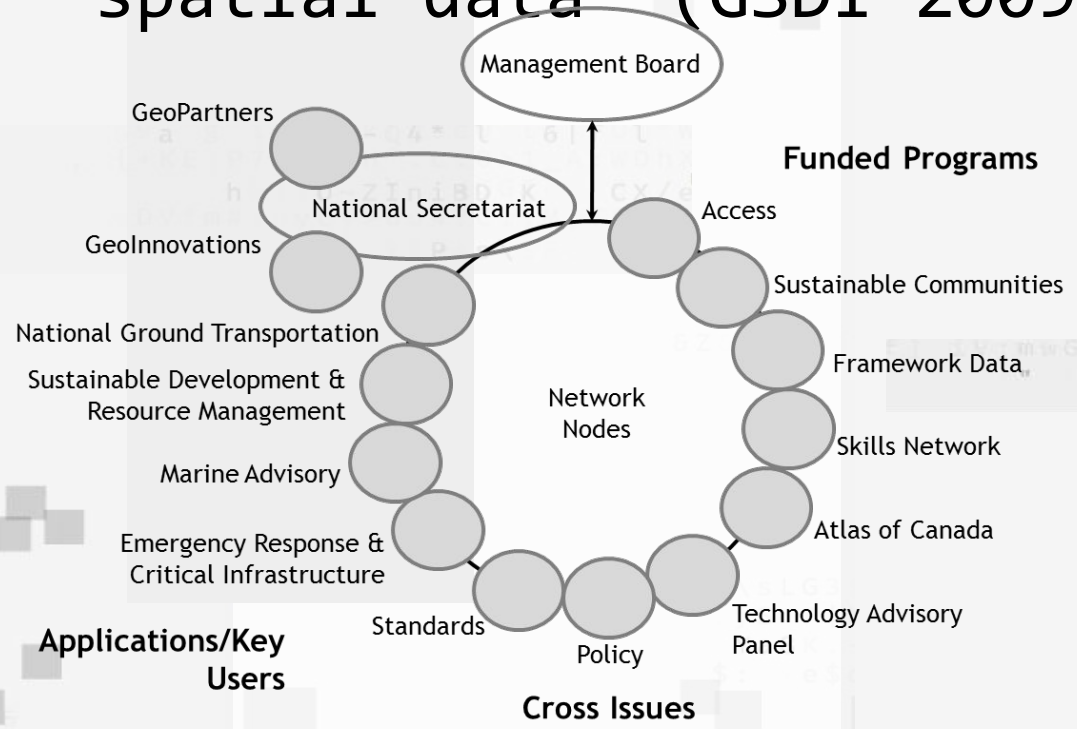
What is a data infrastructure?

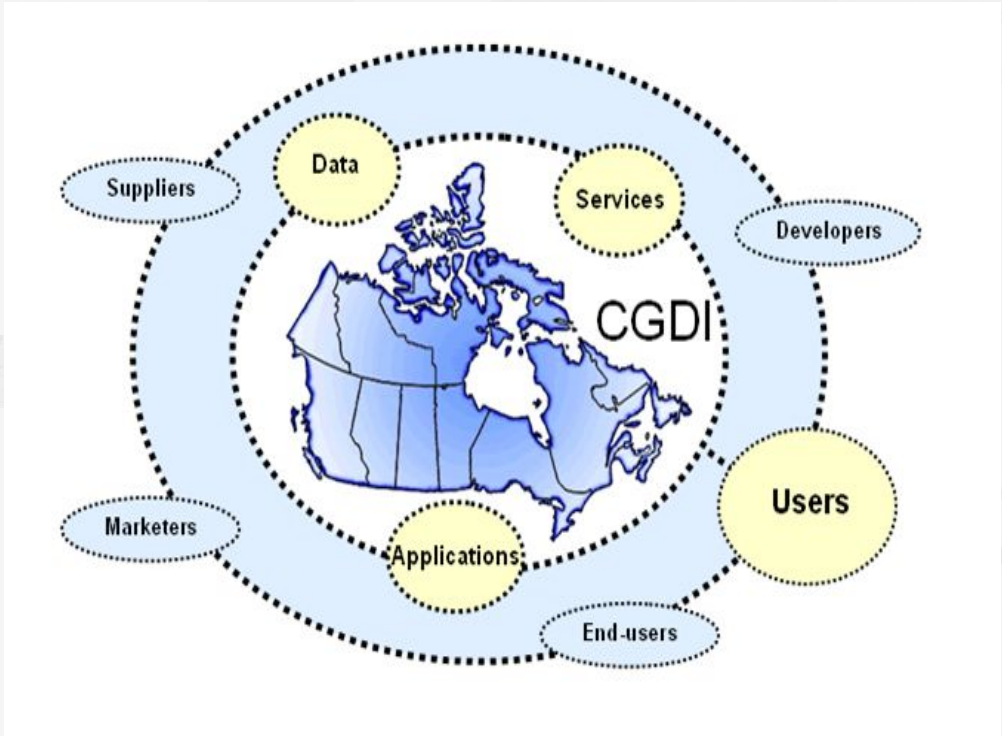
- Complex network of institutional, organizational, technological, human and economic resources, which interact with one another to underpin the design, implementation and maintenance of mechanisms that facilitate the sharing, access to, and responsible use of data for a specific application domain or enterprise (Groot & McLaughlin, 2000).



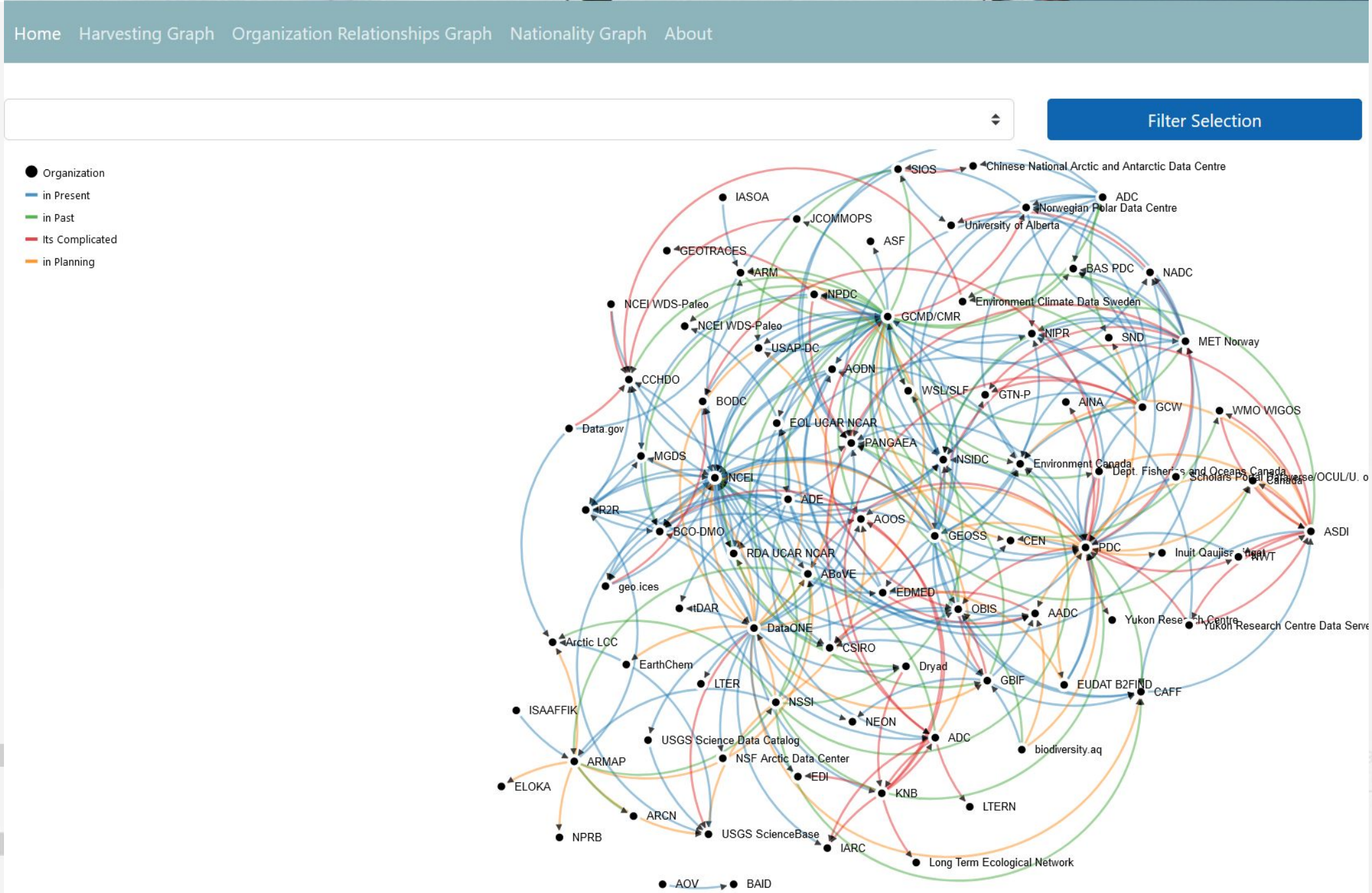
Are related to Spatial Data Infrastructure

- "the relevant base collection of technologies, policies and institutional arrangements that facilitate the availability of, and access to, spatial data" (GSDI 2009)





Regional/Polar Data Infrastructure



ASDI Governance

ARCTIC SDI Arctic Spatial Data Infrastructure

Arctic SDI Services | Map Gallery | Documents | Calendar

Strategic Documents

Who and What is the Arctic SDI?

- 2019-2021 Arctic SDI Biennial Report Highlights from the Icelandic Chairship
- 2017-2019 Biennial Report: Highlights from the Finnish Chairship
- 2015-2017 Biennial Report: Highlights from the US Chairship
- Arctic SDI factsheet September 2018
- Arctic SDI Geoportal Factsheet September 2018

Governing Documents

- Signed Memorandum of Understanding – English, French, and Russian version
- Signed MoU Extention Document 2019 – English, French and Russian version
- Arctic SDI-Governance_v3.1
- Working Group Membership – 2021
- Arctic SDI Organization Feb 2021

Arctic SDI Strategic Plan Documents

- Strategic Plan 2020-2025
- Roadmap and Implementation Plan 2020-2025

Joint Statement of Intent:

- Arctic SDI – Arctic Regional Hydrographic Commission 2020

Arctic Spatial Data Pilot

- Open Geospatial Consortium Spatial Data Pilot with data intensive scenario based videos and a Final Engineering Report

Pan-Arctic Digital Elevation Model

- ArcticDEM – Arctic SDI Board Position Statement
  - Polar Geospatial Center ArcticDEM Documentation

User Needs Assessments

- Environmental Scan on User Needs Assessment for the Arctic SDI
- User Survey Report – Marine and Oceans

Arctic SDI Documentation

- SDI Manual for the Arctic with Glossary of Terms
  - Guidance and information management good practices on commonly accepted SDI operational policies and standards.
  - Audiences: strategic decision makers, data providers, distributors and end users of Arctic data
- Arctic SDI_Glossary of Terms
  - A living glossary providing terms, acronyms, definitions and sources
- **Arctic SDI Evaluation**
  - Arctic SDI Evaluation Report
  - Arctic SDI Evaluation Framework
  - Arctic SDI Evaluation and Benchmarking presentation

Arctic SDI Historical Framework

- Arctic-SDI-Framework-Document_V2 0
  - Provides historical framework and technical vision for the Arctic SDI

Arctic Council stakeholder dialogue and development of the Arctic SDI

- Dialogue with Arctic Council stakeholders identifying needs, requirements and possible contributions
- Develop the Arctic Spatial Data Infrastructure and its map and metadata services providing access to additional reference geodata and thematic data
- Pursue Open Data standards, emerging technologies and industry best practices to remain relevant and interoperable
- Develop governance and guidelines on standards, technical components and services.

2018 News

- Committed engagement in the development of an Arctic Digital Elevation Model (Arctic DEM)
- Initiated cooperation with the Arctic Regional Hydrographic Commission's Arctic Marine SDI Working Group to facilitate access to Arctic marine data and integrate sea and land data

The Arctic SDI cooperation

The Arctic SDI governance model is based on cooperation on prioritized activities where, as agreed to in the Arctic SDI Memorandum of Understanding, activities are developed and managed through the voluntary commitment of each agency. You can learn more about the Arctic SDI at the website: arctic-sdi.org/ .

History of the Arctic SDI

The Arctic SDI concept was introduced in 2007 and the Arctic Council Senior Arctic Officials unanimously gave formal support to the Arctic SDI initiative in 2009. The signing of a Memorandum of Understanding (MOU) in 2014 led to demonstrable progress toward building the first elements of the Arctic SDI and approving a new governance model as well as the Strategic Plan 2015-2020.

The role of the 8 National Mapping Agencies of the Arctic countries

- Provide open access to a coherent and authoritative Arctic reference map and thematic Arctic data through the publication of selected data from their respective holdings and from other sources
- Lead and guide the development of an Arctic Spatial Data Infrastructure to further international SDI best practices.

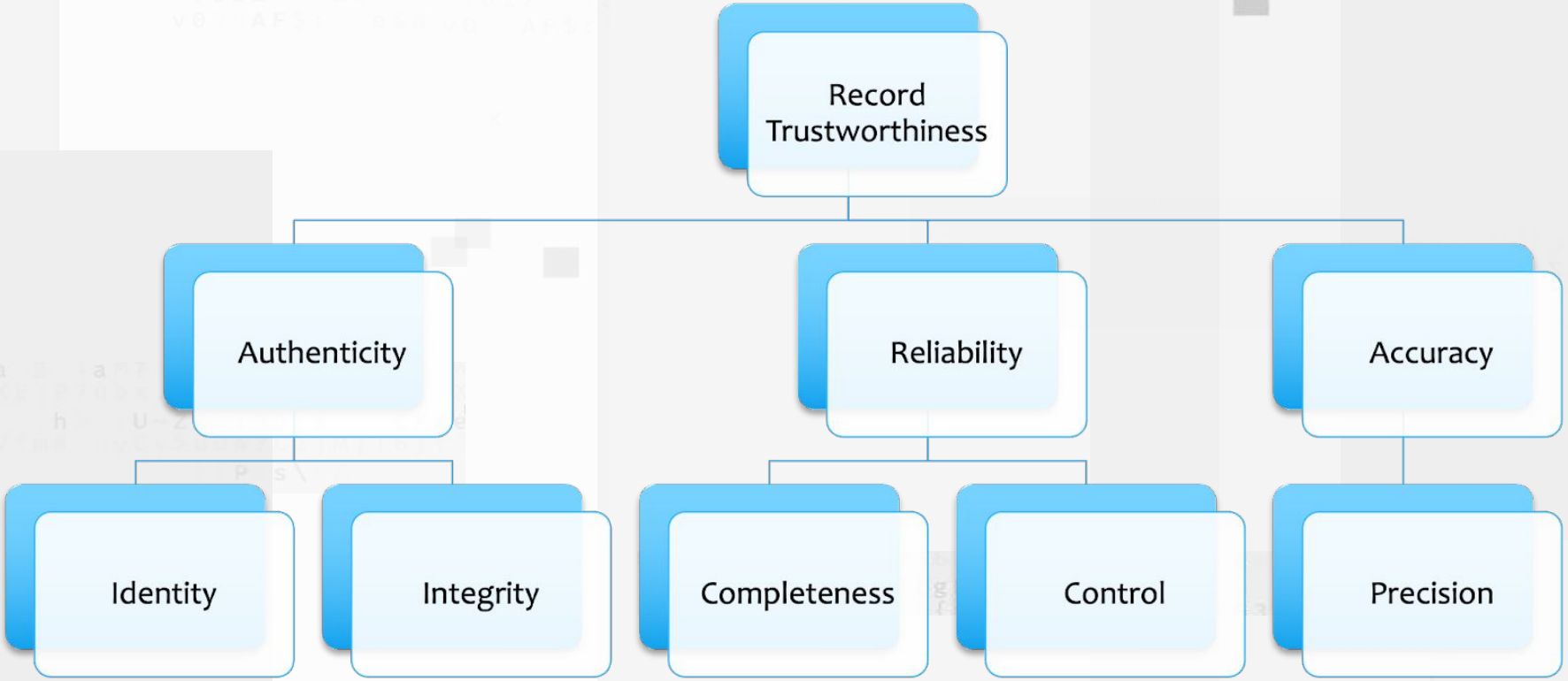
Challenges

Scale

- **Digital Twin**
  - Emergent
  - Maybe distributed or centralized
  - Not yet standardized
  - ACEO, cities, manufacturing
- **Smart City**
  - Establishing
  - Centralized
  - Standardizing
  - Corporate & city actors
- **Spatial Data Infrastructure**
  - Established
  - Federated & Centralized
  - Standardized & Interoperable
  - Government, research and corporate

- **Commonalities**
  - Complex data & technological ecosystems
  - Heterogeneous data
    - Real time data
    - Big & small data
    - IoT
    - Framework
  - Many platforms
  - Standards
  - Multiple types of AI at work
  - Scale shifting
  - Not very standardized
  - Many actors

Assessing Trustworthiness in a complex social and technical system?



Duranti, Rogers, Sullivan, 2022

InterPARES Trust AI

Structure of records in a complex ecosystem?

Medium Physical carrier of the content

Form Rules of representation, both physical and intellectual

Content Message

Act Reason the record exists

Persons Agents participating in the action/record

Archival Bond Relationship of the record to other records participating in the same action

Context Framework of contexts from general to specific in which the record is created and preserved

Form, Function, Structure, Elements of Form, Protocols…

Duranti, Rogers, Sullivan, 2022

Challenge of Archival Studies meets Critical Data Studies

Transdisciplinary Research

- "is defined as research efforts conducted by investigators from different disciplines working jointly to create new conceptual, theoretical, methodological, and translational innovations that integrate and move beyond discipline-specific approaches to address a common problem"

Harvard Transdisciplinary Research in Energetics and Cancer Center, 2022

Q & A

Projects

InterPARES Trust AI, UBC Canada

- Funded by the Social Sciences and Humanities Research Council of Canada, https://interparestrustai.org/trust, @itrustai

Imagining Canada's Digital Twin,

- Carleton Immersive Media Studio (CIMS), Carleton University, Canada
- funded by the New Frontiers in Research Fund (NFRF), https://canadasdigitaltwin.ca

Sustain Designing for People,

- Carleton University, Canada
- funded by NSERC, https://sustain.sce.carleton.ca/

Sensor Systems and Internet of Things Lab,

- Department of Systems and Computer Engineering, Carleton University, Canada
- Funded by CISCO and others https://carleton.ca/internetofthings/people/dr-mohamed-ibnkahla/

Image Source CS04 & CS06

CS03 & CS04 Images come from:

- Cover Slide - CIMS http://cims.carleton.ca/#/projects/imagining_canada's_digital_twin
- Sensor Systems and The Internet of Things Lab presentation at the WG1 Meeting on October 25, 2021 by Zied Bouida.
- Carleton Immersive Media Studio (CIMS) and the presentation at the WG1 Meeting on October 25, 2021 by Nicolas Arellano
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