Toward a

Digital Construction Platform

The Digitalization of National Construction Codes & The Development of a National Common Data Framework

Full Report

buildingSMART Canada | NRC-CNRC

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ÉTS Engineering for Industry

NRC·CNRC

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Abbreviations

Abbreviation	Full title
ACCORD	Automated Compliance Checks for Construction, Renovation, or Demolition Works
AHJ	authority having jurisdiction
API	Application Programming Interface
AR	augmented reality
AWS	Amazon Web Services
BCA	Building and Construction Authority (Singapore)
BCF	BIM Collaboration Format
BIM	Building Information Modelling
BPMN	Business Process Model and Notation
bSC	buildingSMART Canada
bSDD	buildingSMART Data Dictionary
CBHCC	Canadian Board for Harmonized Construction Codes
CCBFC	Canadian Commission on Building and Fire Codes
CCMC	Canadian Construction Materials Centre
CCMS	Component Content Management System
CDBB	Centre for Digital Built Britain
CDE	common data environment
CDF	common data framework
CE	circular economy
CHEK	Change Digital Building Permit
CityGML	An open standardized data model and exchange format to store digital 3D models of cities and landscapes
CSC	Construction Specifications Canada
CSDP	Construction Sector Digitalization and Productivity Challenge program
CSI	Construction Specifications Institute
CSM	Contract Security Manual
DBP	digital building permit
DCP	Digital Construction Platform
D-COM	digital compliance
DITA	Darwin Information Typing Architecture
DTD	Document Type Definition
EPD	Environmental Product Declaration
ÉTS	École de Technologie Supérieure
EUnet4DBP	European network for Digital Building Permit
GDPR	General Data Protection Regulation
GHG	greenhouse gas
GIS	geographic information system

Abbreviation	Full title
GraphQL	A data query and manipulation language for APIs, that allows a client to specify what data it needs
ICC	International Code Council
IDEF	Integrated DEFinition Methods
IDM	Information Delivery Manual
IDS	Information Delivery Specification
IEC	International Electrotechnical Commission
IoT	Internet-of-Things
IFC	Industry Foundation Classes
IR	Information requirements
ISO	International Organization for Standardization
LCA	Life Cycle Assessment
LCCA	Life Cycle Cost Analysis
LCBE	Low Carbon Built Environment Challenge program
LoA	Level of Accuracy
LoC	Level of Completeness
LoC	Level of Coordination
LoD	Level of Development
LoD	Level of Detail
LoI	Level of Information
LOIN	Level of Information Need
LoX	Levels of X
MDA	Model Driven Architecture
NIST	National Institute of Science and Technology
NMCC	National Model Construction Codes
NMS	National Master Specifications
NRC	National Research Council of Canada
OGC	Open Geospatial Consortium
OMG	Object Management Group
openBIM	A collaborative process that is inclusive of all participants, promoting interoperability to benefit projects and assets throughout their lifecycle.
openCDE	a family of standards for providing connectivity and open communication between Common Data Environment platforms and BIM tools for the building and infrastructure sectors in the construction resources industry
OWL	Web Ontology Language
PDCSS	Platform to Decarbonize the Construction Sector at Scale
PDF	Portable Document Format
PIM	project information model
RDF	Resource Description Framework
PTNB	Plan Transition Numérique dans le Bâtiment
REST	Representational State Transfer

Abbreviation	Full title
RESTful API	An interface that two computer systems use to exchange information securely over the internet.
RIM	Regulatory Information Management Framework
RTF	Rich Text Format
SDO	standards development organization
SOAP	Simple Object Access Protocol
STEP	Standard for the Exchange of Product Model Data
SysML	System Modelling Language
TRL	Technology Readiness Level
UID	unique identifier
UCM	Use Case Management
UML	Unified Modelling Language
VR	virtual reality
VRML	Virtual Reality Modelling Language
WIP	work in progress
XML	Extensible Markup Language

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Toward a

Digital Construction Platform

The Digitalization of National Construction Codes & The Development of a National Common Data Framework

Executive Summary

The National Research Council of Canada (NRC) has introduced the Platform to Decarbonize the Construction Sector at Scale (PDCSS) to help the Canadian built asset industry overcome the significant challenges it faces, namely those around sustainability and productivity. Among other things, the platform aims to reduce greenhouse gas (GHG) emissions in construction by developing new low-carbon requirements, incorporating low-carbon solutions into key NRC resources, and supporting their digitalization, thereby supporting the development and deployment of low-carbon construction solutions across the country.

The PDCSS is delivered through two thrusts aimed at fostering a low-carbon industry: (1) The Low Carbon Built Environment Challenge program (LCBE), and (2) The Construction Sector Digitalization and Productivity Challenge program (CSDP). Both thrusts aim to support a low-carbon regulatory context, and ultimately, help the Canadian built asset industry improve its productivity while delivering low-carbon, sustainable built assets.

To operationalize the PDCSS and implement the solutions developed through the program, the NRC aims to leverage the rapid digitalization occurring within the global built asset industry. Accordingly, the NRC aims to develop a digital ecosystem designed to enhance productivity and support the delivery of more sustainable, low-carbon assets within the Canadian built asset industry. More specifically, the NRC aims to promote digitalization in support of decarbonization and productivity increase in the Canadian built asset industry through its three key resource areas for the construction sector: the National Model Construction Codes (NMCC), the National Master Specifications (NMS), and the evaluations and other resources produced by the Canadian Construction Materials Centre (CCMC).

The NRC will therefore develop a Digital Construction Platform (DCP) which aims to digitalize processes and offer services to Canadian built asset industry stakeholders by providing standardized frameworks to facilitate desired outcomes and identify essential services and resources to support them. The NRC DCP will serve as a central repository for these key resources, including the NMS, the CCMC database, and the NMCC. By digitizing these resources and making them accessible through a user-friendly interface, the NRC aims to streamline workflows, facilitate automated compliance checking, improve collaboration tools, and accelerate project delivery.

The objective of the research project presented in this report was to define the NCR DCP and develop a research and development (R&D) roadmap to deliver it.

The primary objectives of the NRC DCP project are:

> **To develop a robust digital infrastructure that supports the management and dissemination of construction codes, standards, and specifications in digital and machine-readable formats.**
>
> **To enhance interoperability among various digital tools and platforms used by industry professionals, regulatory bodies, and government agencies.**
>
> **To promote sustainability through the integration of decarbonization strategies within the construction sector.**
>
> **To streamline regulatory compliance processes using automated tools and enhanced collaboration features**
>
> **To promote and enable collaboration across NRC departments while centralizing and ensuring access to key resources.**
>
> **To establish a foundational architecture and resource pool for the development of interoperable platforms and software tools within the Canadian built asset industry.**

To deliver the project, NRC collaborated with buildingSMART Canada (bSC) and researchers from École de Technology Supérieure (ÉTS) to deliver the NRC DCP R&D Roadmap with a specific focus on the digitalization of the NMCC and the establishment of a National Common Data Framework. The project scope included developing a comprehensive framework as well as an overarching architecture for the NRC DCP. Following the creation of the framework and architecture (the "what"), an R&D roadmap was developed to outline the key actions required to be undertaken by NRC and its collaborators to deliver the NRC DCP (the "how").

To achieve the project objectives, a collaborative and iterative methodology was employed over a 9-month period to develop the NRC DCP and the R&D roadmap.

The key components of the methodology include:

Contextual Analysis:

- Review of Existing Infrastructure: Analyzed NRC's resources, IT infrastructure, platforms, and applications to understand the current state and identify areas for improvement.
- Stakeholder Mapping: Identified and engaged key stakeholders to understand their needs and contributions.

Development and Refinement of Digitalization Scenarios:

- Scenario Development: Developed initial scenarios outlining potential future developments in digital tools and processes within the NRC's ecosystem. These scenarios illustrate how stakeholders might leverage innovative methods to enhance data management, compliance checking, and collaboration.
- Scenario Analysis and Improvement: Continuously analyzed and refined the scenarios based on stakeholder feedback, evolving needs, and new insights to ensure they are practical, relevant, and aligned with project goals.

Stakeholder Engagement and Collaboration:

- Workshops and Meetings: Conducted workshops and meetings with key decision-makers from the Codes, NMS, and CCMC, and other stakeholders to gather insights and validate requirements.
- Feedback Mechanisms: Established channels for ongoing feedback from stakeholders to further refine and improve the NRC DCP and its components.

Documentation and Reporting:

- Documentation: Collected and documented detailed information on digitization scenarios, stakeholder contributions, and system requirements.
- Reporting: Prepared the reports and supporting documents to present the findings, methodologies, and outcomes.

With this project, the NRC is undertaking the development of a digital ecosystem, the DCP, to enhance the efficiency, transparency, and sustainability of the Canadian built asset industry. The proposed DCP is designed to be modular and scalable, leveraging widely accepted resources, standards, and services to ensure a robust and interoperable ecosystem. In terms of architecture, the NRC's DCP is built upon a layered framework that is organized into three tiers, each addressing critical aspects of digitalization within the built asset industry. Figure A illustrates the layered framework which is explained below.

Figure A NRC's Digital Construction Platform layered framework

Tier 1: Common Data Framework (CDF)

The CDF establishes a standardized approach to data management, encompassing semantics, syntax, concepts, processes, practices, and services. This foundational tier ensures coherent and consistent data organization, vital for achieving interoperability across diverse systems within the built asset industry, by clearly defining the resources supporting each key area. Figure B illustrates the key components of the CDF

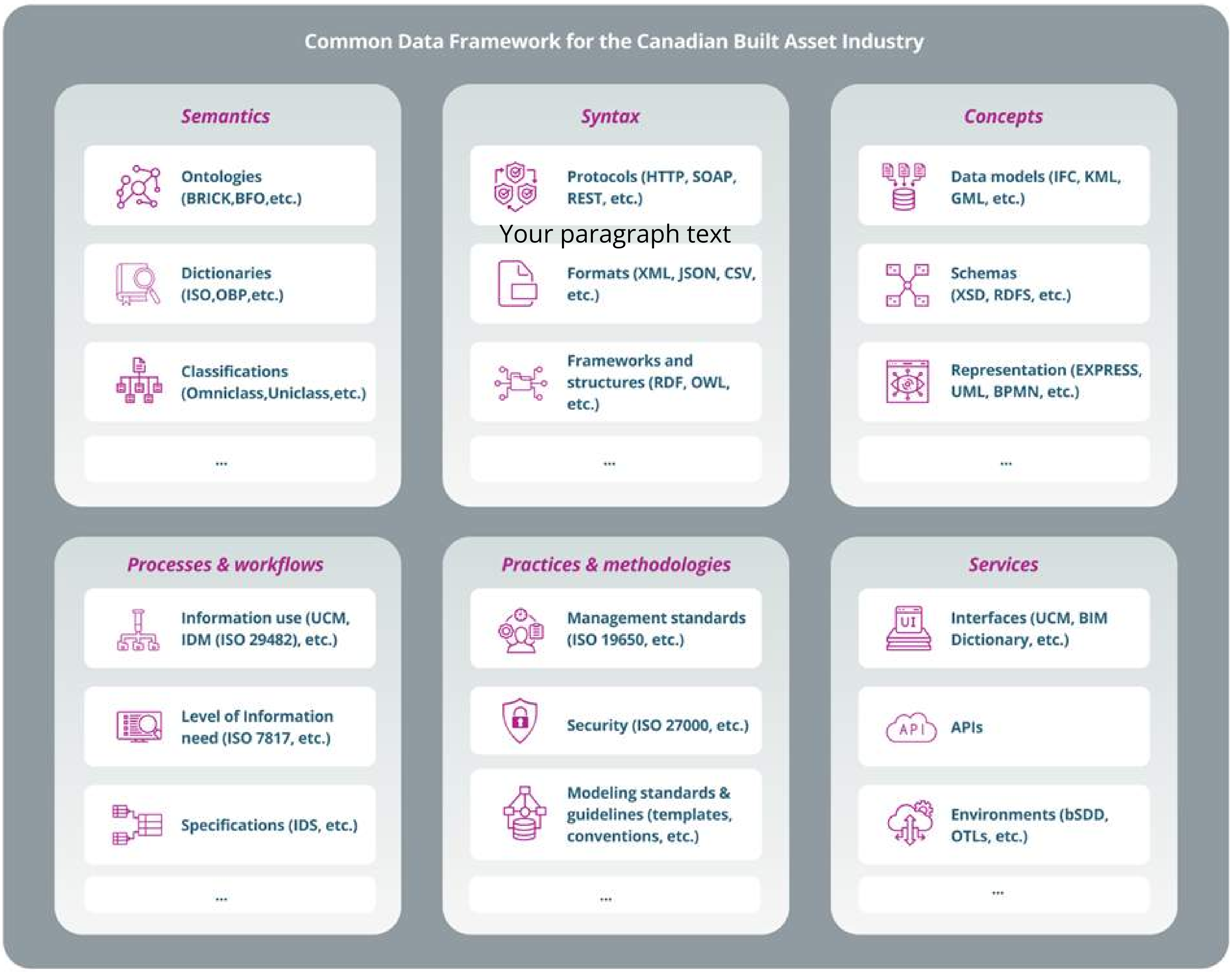


Figure B Common Data Framework for the Canadian built asset industry

Tier 2: Data Exchange / Data Acquisition

uilding on the CDF, Tier 2 focuses on the development of the NRC DCP, a digital "ecosystem" predicated upon the key resources identified in Tier 1 and emphasizing the integration and exchange of data across different Common Data Environments (CDEs). This tier is designed to ensure that the platform supports seamless data flow and communication among stakeholders. It aims to create a scalable and functional platform that centralizes information and enhances collaboration, benefiting NRC as well as other governmental and non-governmental sectors and their platforms. Figure C illustrates the conceptual architecture for the DCP.

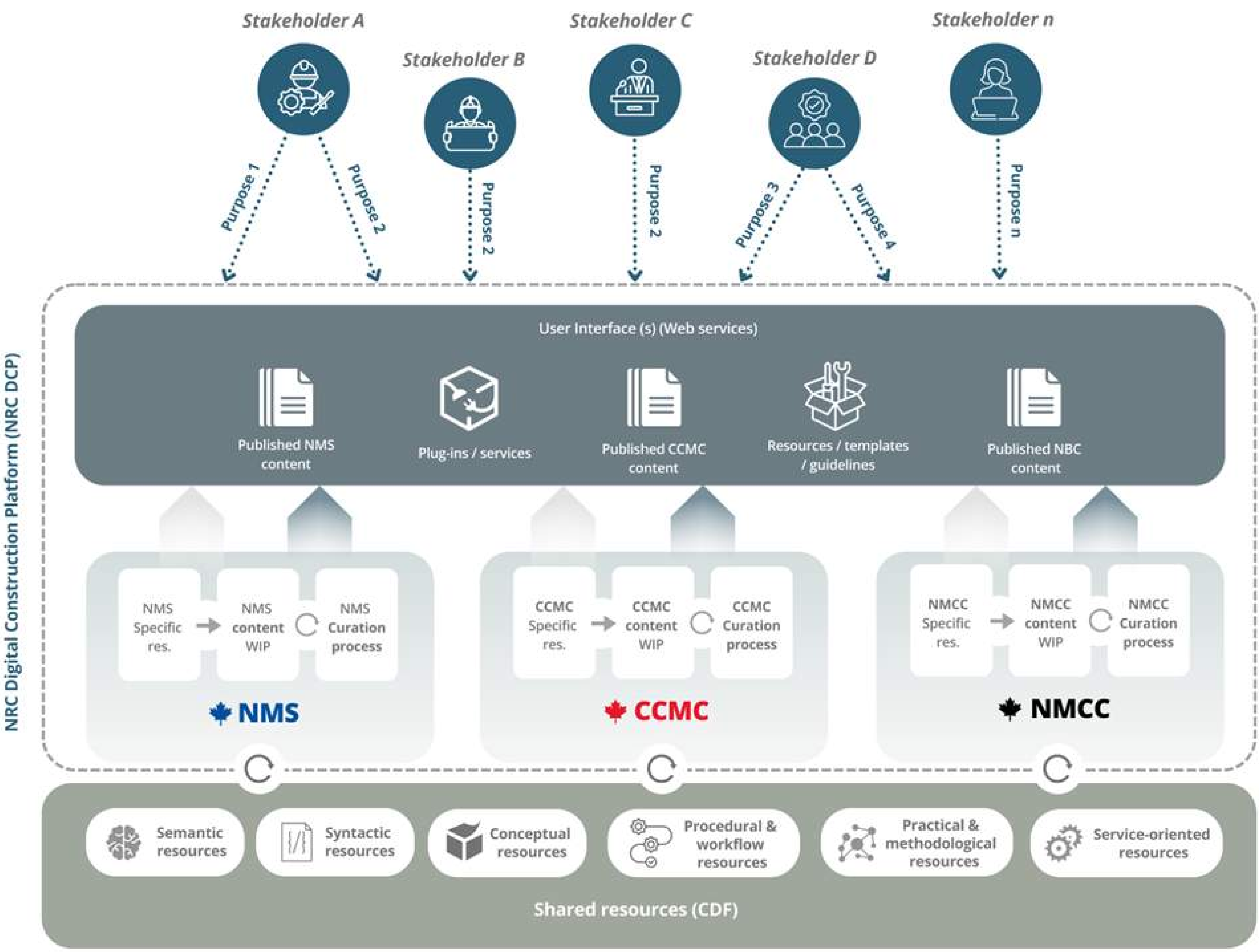


Figure C NRC DCP Conceptual architecture

Tier 3: Data Processing / Data Consumption

Tier 3 addresses the advanced processing and use of data. It involves digital codes, e-permitting processes, and analytical methods like Life Cycle Assessment (LCA) and develops the specific services offered by the DCP. These services are primarily articulated around the three NRC resources being digitalized: the NMCC, the NMS and the CCMC database. Each service is explained, and user scenarios are developed to detail how the DCP should operate. By leveraging the data structures from Tier 1 and the integration capabilities from Tier 2, this tier aims to facilitate comprehensive data analysis and decision-making. It focuses on providing advanced tools for data visualization, reporting, and validation.

The development and implementation of the NRC DCP are guided by a roadmap, articulating 198 activities spanning a six-year period, from 2024 to 2030, and organized into three main streams:

Digital Resources

This stream involves digitizing NRC's resources including NMS, CCMC evaluations, and NMCCs, developing supporting tools, and formalizing digital processes. It ensures that all resources are available and usable throughout the asset lifecycle.

Digital Platform

This includes developing essential functions and services, establishing data exchange standards and integrations, and implementing repositories for data storage and management.

Platform Delivery

This stream covers project governance, capability development, and communication strategies. It ensures effective project management, stakeholder engagement, and the development of necessary training and support materials.

The Roadmap

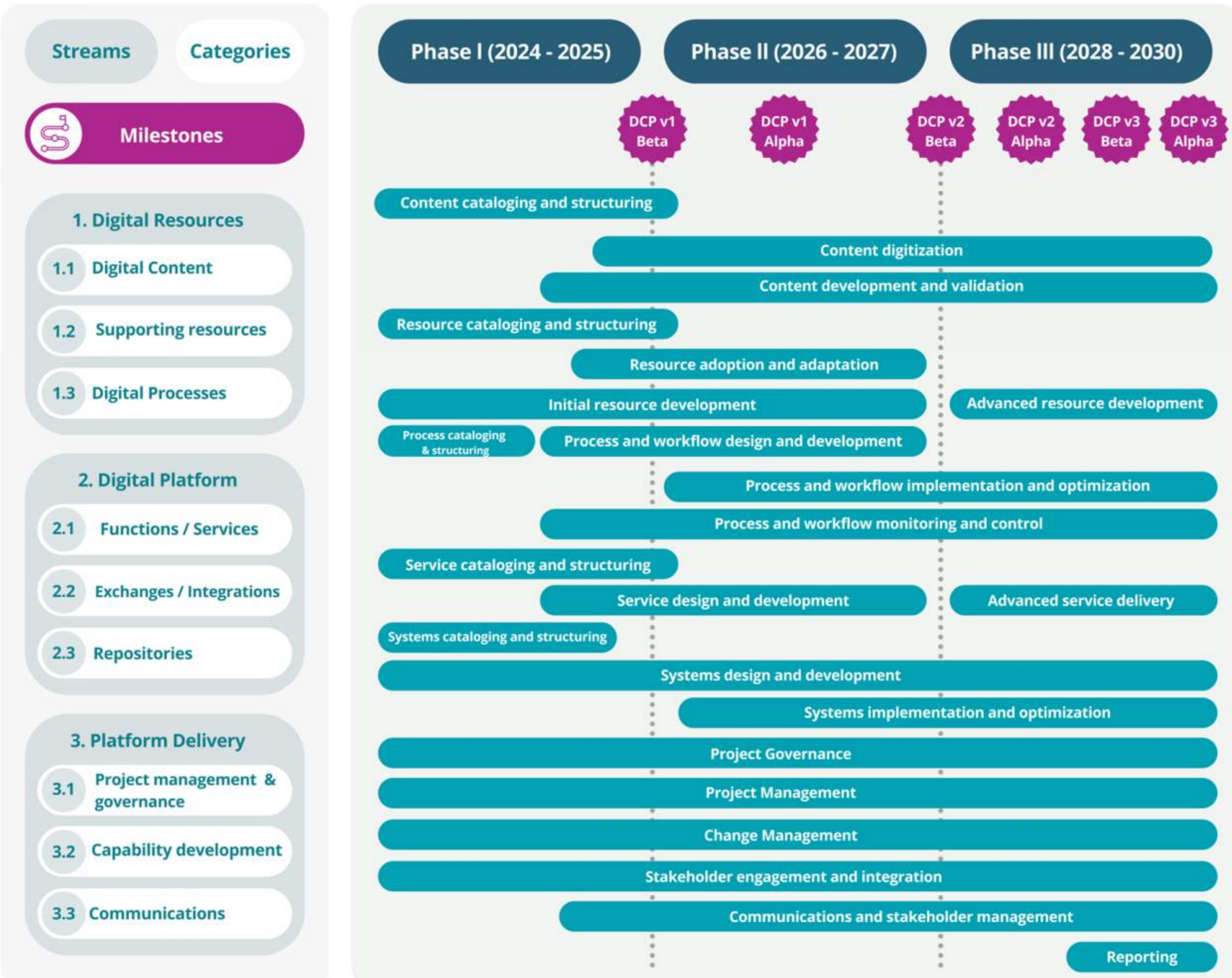


Figure D Proposed High-level DCP R&D Roadmap

The Digital Construction Platform

The NRC DCP initiative involves setting the foundation for improved data and information management, enhancing interoperability of information systems, including Common Data Environments (CDE), and enabling seamless information exchanges among the different stakeholders within the Canadian built asset industry.

The DCP is designed to

Increase productivity and efficiency through streamlined workflows, automated processes, and improved data management.

Improve decision-making by providing access to real-time data and analytics for informed decision-making.

Ensure sustainability by supporting low-carbon construction practices and lifecycle assessment.

Enhance regulatory compliance with simplified building permit processes and automated compliance checks.

Once deployed, it is expected that the NRC DCP will enhance the efficiency, transparency, and sustainability of the Canadian built asset industry. Key outcomes of the DCP include the successful integration of digital specifications, automated compliance checking, and improved data management practices. The DCP will facilitate better stakeholder collaboration and support the decarbonization goals of the construction sector. Additionally, the DCP will be modular and scalable, leveraging widely accepted resources, standards, and services to ensure a robust and interoperable ecosystem.

Full Report

The full report includes a high-level overview of current work in digital ecosystems for the built asset industry, as well as machine-readable building codes, automated code compliance checking, and e-permitting. A current state analysis of NRC's three key resource areas for the construction sector: the NMCC, the NMS, and the CCMC evaluations, focusing on their development and dissemination processes.

The report presents the NRC DCP's target state across its three tiers: the CDF, the Digital Ecosystem, and the Digital Services and Functions, illustrated through specific user scenarios. The platform's requirements are discussed throughout. Finally, the report outlines and discusses the R&D roadmap and implementation plan.

By digitizing these resources and making them accessible through a user-friendly interface, the NRC aims to streamline workflows, facilitate automated compliance checking, improve collaboration tools, and accelerate project delivery.

1. Introduction

The Canadian built asset industry, responsible for the planning, delivery, maintenance and management of Canada's built environment, is facing several significant challenges. Foremost among these are sustainability and productivity. The industry is consistently viewed as underperforming in both areas, marked by stagnating productivity, significant production of waste, and inefficient consumption of resources (Poirier et al., 2022).

Given the significance of these challenges, the National Research Council of Canada (NRC) has introduced the Platform to Decarbonize the Construction Sector at Scale (PDCSS). This platform aims to reduce greenhouse gas (GHG) emissions in construction by developing new low-carbon requirements, incorporating low-carbon solutions into key NRC resources, and supporting their digitalization, thereby supporting the development and deployment of low-carbon construction solutions across the country. The PDCSS is delivered through two thrusts aimed at fostering a low-carbon industry: (1). The Low Carbon Built Environment Challenge program (LCBE), which consists of "a series of initiatives to support the development of low-carbon construction tools, products, and services", aims to promote the development and adoption of low-carbon construction materials and tools for carbon accounting and life cycle assessment, as well as improved low-carbon operation and maintenance practices. (2) The Construction Sector Digitalization and Productivity Challenge program (CSDP), which includes "a series of initiatives to support further modernization and digitalization of Canadian construction sector practices," focuses on accelerating digitalization in construction through research on performance-based codes, developing a digitalization roadmap, and exploring digital tools like portals and virtual inspections (Canada, 2023). Both thrusts aim to support a low-carbon regulatory context. Ultimately, the PDCSS will help the Canadian built asset industry improve its productivity while delivering low-carbon, sustainable built assets.

To operationalize the PDCSS and implement the solutions developed through the program, the NRC aims to leverage the rapid digitalization occurring within the global built asset industry. By benefitting from the growing consensus and availability of resources, NRC seeks to structure, guide, and promote this digitalization. Indeed, digital tools and platforms are essential for addressing the challenges. Accordingly, the NRC aims to develop a digital ecosystem designed to enhance productivity and support the delivery of more sustainable, low-carbon assets within the Canadian built asset industry. More specifically, the NRC aims to promote digitalization in support of decarbonization and productivity increase in the Canadian built asset industry through its three key resource areas for the construction sector: the National Model Construction Codes (NMCC), the National Master Specifications (NMS), and the evaluations and other resources produced by the Canadian Construction Materials Centre (CCMC) .

The objective of the research project presented in this report was to develop a research and development (R&D) roadmap to deliver the NRC'S Digital Construction Platform (NRC DCP). The primary objectives of the NRC DCP project are:

7. To develop a robust digital infrastructure that supports the management and dissemination of construction codes, standards, and specifications in digital and machine-readable formats.
8. To enhance interoperability among various digital tools and platforms used by industry professionals, regulatory bodies, and government agencies.
9. To promote sustainability through the integration of decarbonization strategies within the construction sector.
10. To streamline regulatory compliance processes using automated tools and enhanced collaboration features.
11. To promote and enable collaboration across NRC departments while centralizing and ensuring access to key resources.
12. To establish a foundational architecture and resource pool for the development of interoperable platforms and software tools within the Canadian built asset industry.

buildingSMART Canada (bSC), in collaboration with researchers from École de Technology Supérieure (ÉTS), was engaged by NRC to deliver the NRC DCP R&D Roadmap with a specific focus on the digitalization of the NMCC and the establishment of a National Common Data Framework. The project scope included developing a comprehensive framework as well as an overarching architecture for the NRC DCP. Following the creation of the framework and architecture (the "what"), an R&D roadmap was developed to outline the key actions required to be undertaken by NRC and its collaborators to deliver the NRC DCP (the "how").

To achieve the project objectives, a collaborative and iterative methodology was employed over a 9-month period to develop the NRC DCP and the R&D roadmap. The key components of the methodology include:

5. Contextual Analysis:
    - **Review of Existing Infrastructure:** Analyzed NRC's resources, IT infrastructure, platforms, and applications to understand the current state and identify areas for improvement.
    - **Stakeholder Mapping:** Identified and engaged key stakeholders to understand their needs and contributions.
6. Development and Refinement of Digitalization Scenarios:
    - **Scenario Development**: Developed initial scenarios outlining potential future developments in digital tools and processes within the NRC's ecosystem. These scenarios illustrate how stakeholders might leverage innovative methods to enhance data management, compliance checking, and collaboration.

- **Scenario Analysis and Improvement**: Continuously analyzed and refined the scenarios based on stakeholder feedback, evolving needs, and new insights to ensure they are practical, relevant, and aligned with project goals.

7. Stakeholder Engagement and Collaboration:
    - **Workshops and Meetings:** Conducted workshops and meetings with key decision-makers from the Codes, NMS, and CCMC, and other stakeholders to gather insights and validate requirements.
    - **Feedback Mechanisms:** Established channels for ongoing feedback from stakeholders to further refine and improve the NRC DCP and its components.
8. Documentation and Reporting:
    - **Documentation:** Collected and documented detailed information on digitization scenarios, stakeholder contributions, and system requirements.
    - **Reporting:** Prepared the reports and supporting documents to present the findings, methodologies, and outcomes.

With this project, the NRC is undertaking the development of a digital ecosystem, the DCP, to enhance the efficiency, transparency, and sustainability of the Canadian built asset industry. The DCP is modular and scalable, leveraging widely accepted resources, standards, and services to ensure a robust and interoperable ecosystem. Once operational, key outcomes of the DCP include the successful integration of digital specifications, automated compliance checking, access to key resources and improved data management practices across the Canadian built asset industry. Ultimately, the DCP aims to facilitate better stakeholder collaboration and support the decarbonization goals of the construction sector.

This report begins with a high-level overview of current work in digital ecosystems for the built asset industry, as well as machine-readable building codes, automated code compliance checking, and e-permitting. It then provides a current state analysis of NRC's three key resource areas for the construction sector: the NMCC, the NMS, and the CCMC evaluations, focusing on their development and dissemination processes. The report presents the NRC DCP's target state across its three tiers: the Common Data Framework (CDF), the Digital Ecosystem, and the Digital Services and Functions, illustrated through specific user scenarios. The platform's requirements are discussed throughout. Finally, the report outlines and discusses the R&D roadmap and implementation plan.

2. Background

The NRC's effort to support the digitalization of the Canadian built asset industry is aligned with various efforts and initiatives currently underway around the world. This section provides a review of key initiatives that pursue objectives similar to those identified by the NRC. This review aims to, among other objectives, identify the potential areas where NRC could benefit or leverage the developments of these projects. The review covers two main topics: the development and implementation of digital ecosystems and the digitalization and automation of code compliance checking and e-permitting. Global initiatives, such as those spearheaded by the Building and Construction Authority (BCA) in Singapore, the DigiPLACE, the ACCORD and CHEK projects in the European Union, and the CDBB Reference Architecture Framework, among others, provide robust precedents that can serve to inform and enrich the NRC's initiative.

Before reviewing the relevant initiatives, certain concepts and terminology must be clarified. A Common Data Environment (CDE) is defined as a shared digital space that facilitates collaboration, information exchange, and communication throughout the project lifecycle. It consists of three key components: the Data Standard, which specifies the required information for a project and its structure to ensure effective sharing and collaboration; the Data Platform, which is the technological foundation of the CDE, serving as the repository for project data, enabling storage, sharing, and collaborative use, and the workflow or process, which establishes how information is curated, accessed and exchanged within the CDE. A CDE Use Case refers to specific digital workflows within a CDE designed for managing project information. Deliverables are the tangible outputs generated from various CDE use cases. The term Digital Use Case signifies a project sub-task that has been adapted for digital execution within the CDE. Integrated Digital Delivery (IDD) represents the strategic use of digital technologies to integrate workflows and connect all project stakeholders. A Performance Metric is a quantifiable measure used to assess the effectiveness of specific actions within the project. Finally, Project Activity denotes the typical tasks undertaken during a project, which can be applied at specific stages or across various stages (BCA, 2021).

Under the Horizon Europe Program (formerly the Horizon 2020 Program) the European Union has been supporting multiple projects which pursued similar aims to NRC's. A recent article[1] on the European Commission's website identifies these projects, which are summarized in Table 1.

[1] https://build-up.ec.europa.eu/en/resources-and-tools/articles/overview-article-digital-transformation-built-environment-and-0 (Accessed on July 31, 2024)

Table 1 List of EU-Funded projects promoting digitalization in the built asset industry (source: European Commission, 2024)

Initiative	Description
HumanTech project	"Proposes the use of **human-centred technologies** to improve the safety and wellbeing of the construction workforce, while also increasing productivity and efficiency. The project calls for **automation** to increase precision and avoid human errors to optimise the use of building materials."
DigiChecks project	"Proposes a digital framework that implements different steps to manage the process of permits and compliance checks in the construction industry. "
DigiBUILD project	"Aims to transform buildings into smart buildings by making use of high-quality data and next generation building services, supporting the **EU framework of Digital Building Logbook**. The project will provide an open, interoperable and cloud-based toolbox to transform buildings into digital and smarter buildings, while supporting informed decision-making."
SMARTeeSTORY project	"Proposes a multi-domain methodology to monitor and optimise non-residential historic buildings´ energy performance. This approach will integrate smart readiness indicator domains, such as heating, ventilation and air conditioning, dynamic façade, and lighting."
ARtwin project	"Aimed at developing **Augmented Reality (AR) cloud platform** for improving productivity and product quality of the European Construction 4.0. AR operated on a large scale by using 3D mapping and vision-based location services. A remote rendering service allowed the representation of 3D content. The developed platform maintained in-real time Digital Twin of the factory or BIM of the building."
DigiPLACE project	"Aimed at developing a **framework** for future digital platforms as common ecosystems for digital services to support innovation. It eventually defined a Reference Architecture Framework for digital construction platform involving a large community of stakeholders."
BIMERR project	"Designed and developed a **Renovation 4.0 toolkit** which comprises tools to support renovation stakeholders throughout the renovation process of existing buildings. The tools support the creation of enhanced building information models, renovation support system giving an accurate estimation of the renovation impact on building performance and a process management tool."
BIM-SPEED project	"Aimed to develop a combination of methodologies and tools with one central information source, that is **Building Information Modelling** which would make deep renovation of residential buildings smarter and more efficient."
BIM4EEB project	"Aimed to foster the renovation of buildings through a powerful **BIM-based toolset** able to support designers, construction companies and service companies. Moreover, thanks to the exploitation of augmented reality and the use of digital

Initiative	Description
	building logbooks public and private owners were able to use a tool to ease decision making and asset management."
BIMprove project	"Aimed to move beyond Building Information Modelling and improve efficiency and outcomes in building and construction planning and operation with **digital twin technologies**."
BIM4REN project	"Defined digital ready renovation workflows for the construction sector needs and elaborated an open BIM environment for data collection, data management and data driven design. An Open Stop Access Platform was then developed to integrate all technologies as a single-entry point for all users."
EERAdata project	"Aimed to accelerate the implementation of the Energy Efficiency First principle by developing a decision-support tool to help local administrations in their collection and assessment of building and demographic data for a prioritisation of energy efficiency measures in renovation of buildings. The tool is able to model and assess the impact of energy efficiency investment in buildings."
BuildUPspeed project	(funded under the LIFE programme (LIFE21-CET-BUILDRENO) "Aims to accelerate and support deep renovation of the EU building stock by introducing a Market Activation Platform for the promotion and implementation of industrialised renovation solutions. In particular, the project will capitalise on results of other projects on BIM for renovation and Industry 4.0."

Among these projects, the DigiPLACE (digital ecosystem) and DigiCHECK (automated code compliance checking) projects are most related to the NRC DCP initiatives, whereas the other projects are relevant to the overall PDCSS. *The DigiPLACE Project* (2019-2021) aimed to develop a "framework allowing the development of future digital platforms as common ecosystems of digital services that will support innovation, commerce, etc." The principal outcome of the project was the development of a "Reference Architecture Framework for digital construction platform based on an EU-wide consensus involving a large community of stakeholders, resulting in a strategic roadmap for successful implementation of this architecture." (DigiPlace, 2019) The proposed Reference Architecture Framework (Figure 1) provides a blueprint for interoperable construction platforms and sets common guidelines to facilitate the development and deployment of interoperable digital platforms within the European construction sector. It focuses on several key areas, including general implementation principles that emphasize interoperability, open standards, and data security and privacy measures. The DigiPLACE framework is predicated upon open standards to enable seamless information flow across all project stages, in an effort to avoid data silos and facilitate the creation of interoperable digital twins that integrate data from various disciplines. Additionally, it identifies essential tools and services that support core project use cases within the CDE and underscores the importance of aligning with EU and Member State legal and regulatory frameworks (Mirarchi et al., 2021).

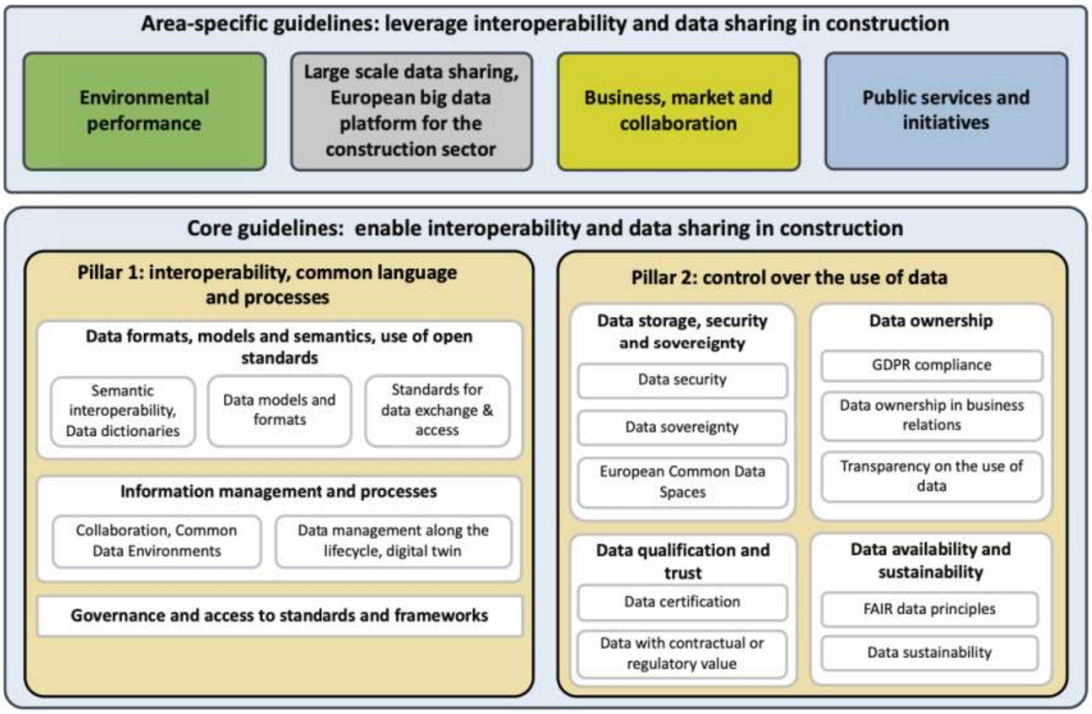


Figure 1 Overview of the DigiPlace Reference Architecture Framework (Taken from Mirarchi et al., 2021)

The DigiPLACE framework also emphasizes the importance of realizing BIM-based Life Cycle Assessment (LCA). This aligns with the ongoing development of ISO/DIS 22057, a standard for Environmental Product Declarations (EPDs), specifically tailored for BIM. By integrating LCA data into BIM models, sustainability can be promoted during design, construction, and facility operation. This holistic approach to sustainable construction practices aligns with NRC's goal of improving productivity and supporting decarbonization (*DigiPLACE 2021 Booklet*, 2021).

In the United Kingdom, the Center for Digital Built Britain (CDBB), in collaboration with the Construction Innovation Hub, pursued similar efforts to support digitalization within the UK built asset industry. The 5-year initiative covered several themes: (1) Digital Built Environment, aimed at management of the UK built environment for the whole life performance, (2) Digital Infrastructure, to enable the secure connection of diverse data sources, (3) Digitally Enabled Living, to investigate social issues in the light of digital transformation, (4) Data Science, Artificial Intelligence, Machine Learning to enable automated and smart management of the built environment, and (5) Digital Twins, to support better decisions about assets and complex systems. Many of the works are relevant to the NRC DCP as they lay out foundational concepts, offer a thorough review of existing resources and propose solutions within the themes described above. Of note, survey papers were published on ontologies (Partridge et al., 2020) as well as data models and reference data libraries (Leal et al., 2020), which served to inform a foundational data model for the CDBB information management framework as part of the National Digital Twin Framework (West et al. 2020).

Building on these resources, CDBB proposed key building blocks in the UK's National Digital Twin (Figure 2), namely an Information Management Framework, supported through an integration architecture (Heatherington and West, 2020) and key architectural requirements for the UK'S National Digital Twin (Kendall, 2021). While digital twins are beyond the scope of this research project, their principles and requirements are considered within the NRC DCP for future extensions and developments. In parallel, the Digital Compliance (D-COM) project aimed to support the digitalization and automation of the compliance checking process, namely by identifying requirements and defining capabilities to do so. The requirements for automated compliance checking identified in D-COM are included in the NRC DCP and NMCC digitalization efforts.

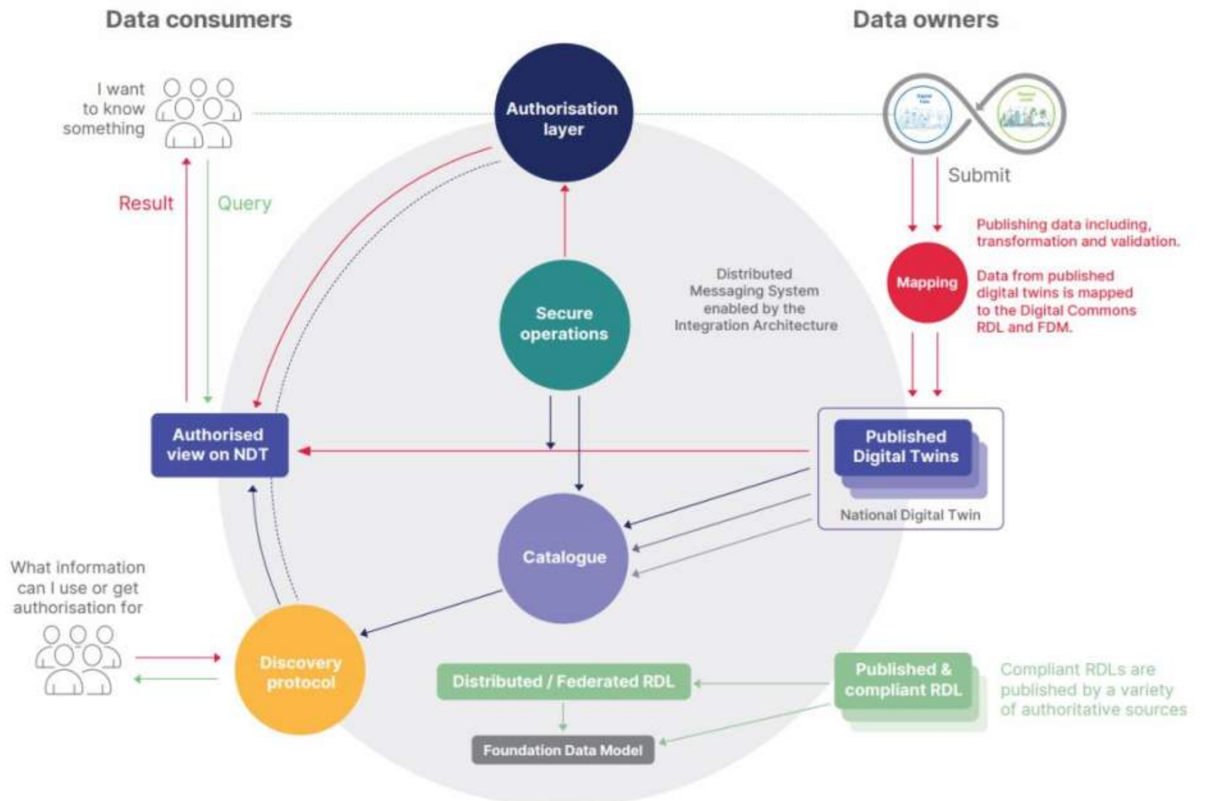


Figure 2 Conceptual View of the NDT – A National Digital Twin enabled by an Information Management Framework (Taken from CDBB)

Several other government bodies have looked at developing and providing digital ecosystems to enable digitalization within their regions'-built asset industries. For example, the Estonian government has been leading the development of an e-construction platform as part of its long-term strategy to triple the productivity of its construction industry by 2030 (CIVITTA, 2018b, 2018a; Jaanisoo, 2021). Another example is the Catalan government's Oura Project which proposes a Digital Construction Ecosystem (IAAC BLOG, 2024) to tackle three core challenges in the built asset industry: (1) Increasing Relevant

Data in the Fabrication Stage to optimize material production processes, reduce waste, and significantly cut down on carbon emissions by implementing advanced tracking and data analysis techniques, (2) Implementing Product Passports for Material Longevity, product passports being digital documents that provide a comprehensive history of materials, including their origin, composition, and previous uses, and (3) Optimizing Transportation for Short and Long Distances to address the inefficiencies in material transportation through an integrated logistics solution that optimizes transportation routes for both short and long distances (Boy et al., 2024). The Oura project is relevant to the NRC DCP due to its focus on decarbonization and digitalization, specifically Product passports in the context of the CCMC.

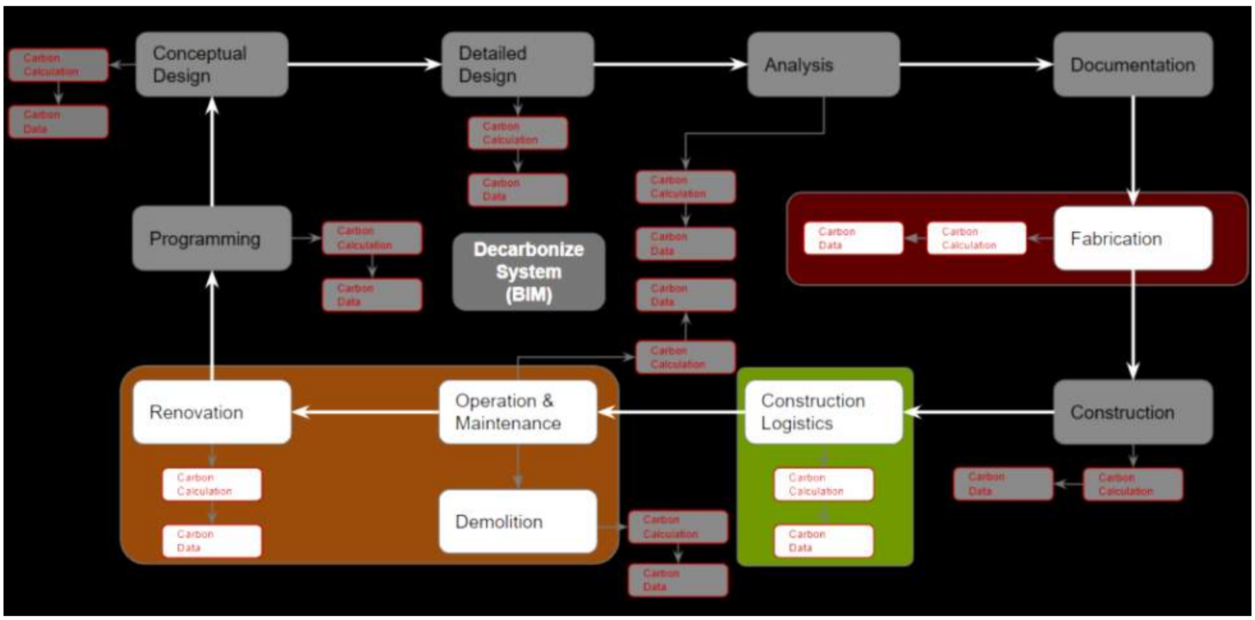


Figure 3 The Catalan government's Oura Project (Taken from Boy et al, 2024)

Other government initiatives have adopted pragmatic approaches to digital transformation. For instance, the French initiative 'Plan Transition Numérique dans le Bâtiment' (PTNB), which evolved into 'PlanBIM', focused on supporting SMEs across France. As part of this effort, they developed 'Kroqi', a free-to-use CDE based on open standards. Kroqi offers a suite of core functionalities and supports a modular architecture, serving as a collaborative platform for construction professionals (*Plateforme collaborative des pros de la construction*, nd). The *Kroqi* platform has now become its own entity and charges a nominal fee for use but remains highly accessible. The *Kroqi's* development is relevant to the NRC DCP as it exemplifies a government-led initiative aimed at providing a low-cost alternative for a CDE supporting open standards and implementing a modular architecture.

The BCA of Singapore has been addressing the challenge of inconsistent information requirements across building projects over the last decade, which often forces project teams to adapt to varying data sets and standards mandated by different client bodies. This inconsistency leads to inefficiencies and wasted time in deciphering project-specific information requirements. To overcome this, the BCA, in partnership with industry stakeholders, established standardized information requirements for use within CDEs. By standardizing information requirements and establishing a collaborative environment, the BCA has streamlined project delivery and lifecycle management of assets, promoting efficiency and consistency (BCA, 2021). This approach aligns closely with NRC's objectives to digitalize the Canadian built asset industry, improve productivity, and support decarbonization.

The global landscape of digitalized and automated code compliance checking is rapidly evolving, driven by a shared willingness among organizations and countries to improve efficiency, sustainability, and safety within the industry. Notable projects include the ACCORD project, the CHEK project, the previously mentioned D-COM Network and the DigiChecks project. Appendix 2 provides an overview of the automated code compliance checking process and requirements.

The ACCORD project (Automated Compliance Checks for Construction, Renovation, or Demolition Works) aims to streamline building permitting and compliance processes using BIM and diverse data sources. Its primary objective is to enhance productivity and quality in design and construction, promote climate-neutral buildings, and support a sustainable built environment. The project is developing a semantic framework for European digital building permitting processes, regulations, data, and tools, facilitating the formalization of rules and the integration of existing compliance tools as microservices (Breitenfelder et al., 2023).

The ACCORD framework includes several essential components for digitalizing building permitting and compliance processes. It begins with a Rule Formalization Process that converts building codes into machine-readable formats. Data Dictionaries organize key terms from these codes, enhancing access and utilization efficiency. The Building Compliance Ontology defines core concepts essential for interpreting building codes, complemented by the Domain Specific Rule Language, which provides a structured approach to articulating rules. This results in Formalized Building Codes and Rules that are machine-readable and easily accessible (Dridi et al., 2023).

The framework also includes Cloud-Based Permitting Service User Interfaces, providing platforms that enable stakeholders to interact with the permitting system. Additionally, Model and Data Requirement Validation ensures the accuracy and completeness of submitted building models, critical for regulatory compliance. Process Execution manages the entire building permitting process, ensuring operational streamlining and adherence to established rules and timelines. Data Storage centralizes all relevant data used during permitting, promoting efficiency and data integrity (Al-Doori et al., 2024).

Furthermore, Orchestrating Microservices plays a key role in coordinating specialized compliance checks, enhancing the framework's adaptability and effectiveness. Compliance Checking Services conduct rigorous checks to ensure buildings meet regulatory standards, ensuring safety and compliance. APIs facilitate smooth communication and integration between framework components, promoting interoperability and overall functionality. ACCORD's comprehensive approach to digital building permitting and compliance, emphasizing user requirements and seamless information flow, provides valuable insights into enhancing construction industry practices.

Similarly to ACCORD, the CHEK project is a collaborative effort, aiming to overcome the current barriers to adopting digital building permit processes. Many partners are already collaborating within the European network for Digital Building Permit (EUnet4DBP), sharing experiences, coordinating efforts, and addressing challenges to develop a unified strategy for digital building permits. Figure 4 illustrates the 5 development areas addressed in the CHEK project (*Change Toolkit for Digital Building Permit - CHEK*, 2022).

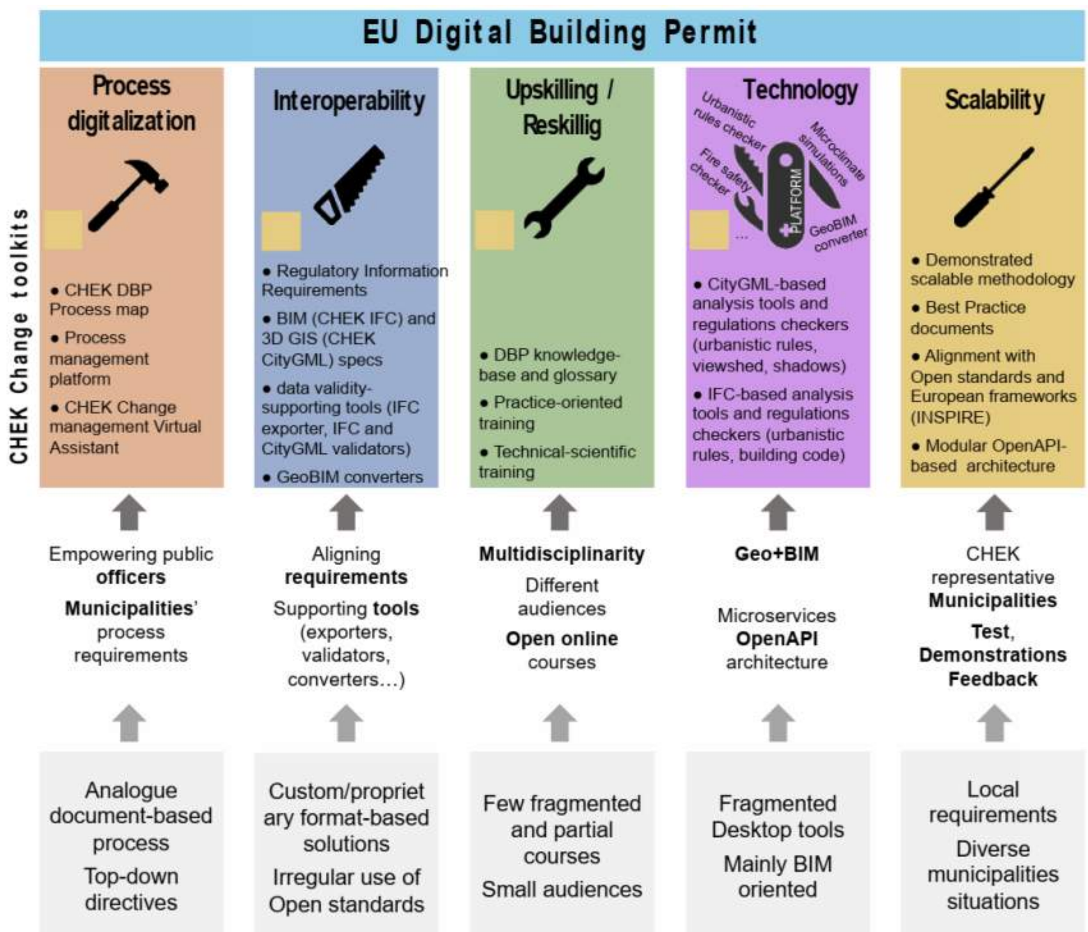


Figure 4 CHEK project: Change toolkit for Digital Building Permit (Taken from CHEK, 2022)

The CHEK project aims to remove barriers to the adoption of digital building permit processes by creating scalable solutions that address regulatory and policy contexts, open standards, interoperability, education, municipal processes, and technology deployment, ultimately achieving Technology Readiness

Level (TRL). The project will provide a toolkit to digitize building permitting and automate compliance checks for building designs and renovations in European urban areas (Figure 5). The project goals include developing digital building permit processes, aligning digital technologies with municipal processes, creating open standards for data exchange, upskilling and reskilling officers and users, and demonstrating the scalability of the solutions. Key components of the project include a TO-BE process map illustrating the CHEK DBP process from information collection to updating the as-built model in the city model, a maturity model (CDBPMM) for assessing and improving digital building permit processes, and the CHEKWiki platform for upskilling and improving communication within the project.

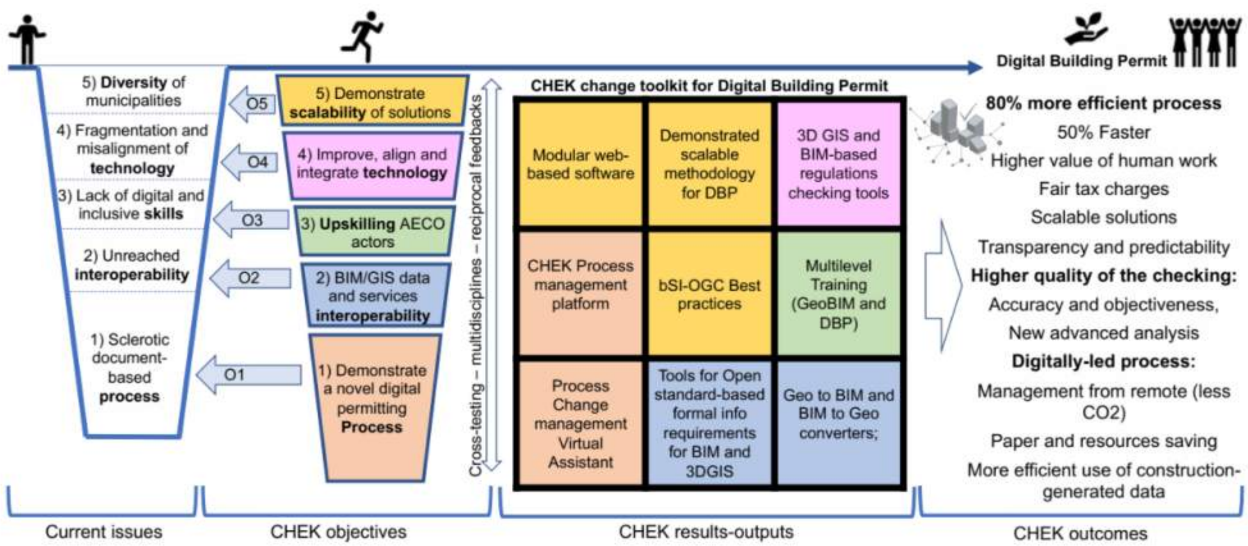


Figure 5 CHEK project, current issues, objectives, results and outcomes (Taken from CHEK, 2022)

Additionally, CHEK is focused on developing specific BIM and 3D city models based on clearly defined Regulatory Information Requirements and streamlining the delivery of regulatory analysis information through CHEKClauses. The project also includes the development of various software tools to support the digital building permit process. These tools range from open APIs for BIMserver.center to facilitate data access and management, to the IFC CHEK tool for standardized automated validation through IDS and PSD files. Other tools include the CYPEURBAN program for creating urban planning compliance documents, Open BIM Accessibility for verifying accessibility requirements, and the IFC to CityGML converter for transforming building models for better interoperability. By integrating these elements, the CHEK project aims to enhance the efficiency, quality, and transparency of building permit processes, supporting municipalities in their digital transformation journey.

Finally, several countries have developed specific e-permitting initiatives, a selection of which is shown in Table 2. The table shows the leading authorities in the selected countries that have implemented digital permitting processes as well as the different components making up the system. Required data formats as well as support of open BIM principles are also shown.

Table 2 International initiatives on Construction Digital Regulatory Systems (Source: Shahi et al 2019)

	Singapore	Norway	United Kingdom	South Korea
Establishing e-Submission platform	Yes, CORENET (1995-)	Yes, eByggesøk (building applications) (2003-)	Yes, Planning Portal (2002-)	Yes, SEUMTER (2009-)
Lead authority	Building & Construction Authority	Norwegian Building Authority	UK government	Ministry of Land Infrastructure and Transport in Korea (MOLIT)
Components	e-Submission, e-Plan Check, and CORENET e-Info	Information system, system for submitting building applications, and system for zoning proposals	Online access to planning information, online submission of planning and building control applications	Initially based on 2D drawings, expanding towards BIM-based submission
Mandatory BIM policy	Required for new buildings that are more than 5000 m² since 2015	Mandated on all public sector projects since 2010	Model-based BIM (level 2) mandated on all public sector projects in 2016	Mandated by Public Procurement Service since 2016
Required data format	Native File Format and Lightweight File Format	IFC, Native	COBie, Native, PDF	IFC, native
Based on IFC or openBIM	The CORENET System worked with IFC building models in 1998	Pilot projects started to use IFC in the early 2000s	The target date for public sector adoption of openBIM is 2025	Under development
Current research and development activity	tenders for rule-based code compliance checking for BIM models in 2016, currently active CORENET-X t in 2020	Created a new version of ByggLett, termed ByggLett 2, completed in 2017	Formation of the (D-COM) network to advance digitization of regulations and compliance checking systems	Working to improve SEUMTER to be a BIM-based e-Submission and automated code compliance checking system

This review of initiatives demonstrates that the issues being addressed through the NRC PDCSS, and more specifically the CSDP, have been tackled by various initiatives worldwide. As such, NRC can learn from these initiatives and leverage their findings and solutions that have been developed. The key takeaways from this review are:

- Numerous global initiatives demonstrate that governments recognize the value of developing common digital ecosystems for the construction industry, aimed at streamlining and facilitating information exchanges.
- Many of the foundational resources required to develop such digital ecosystems have been identified and/or developed through past initiatives. Most of these are open source and available for use.
- Efforts aimed at digitalizing construction codes and making them machine readable are ongoing in many jurisdictions worldwide. NRC is therefore not alone in pursuing this endeavour and can leverage lessons learned from these other jurisdictions.
- A robust digital foundation can enable the development of multiple services, offering diverse capabilities and functionalities to Canadian built asset industry stakeholders. This foundation should be developed to be modular, open and scalable, while facilitating the integration of different data sources and information systems.

3. Current State Analysis

The NRC DCP, which encompasses the digitization of the NRC's key resources relating to the built environment, is to be delivered within the NRC's operational context. It is therefore important to understand this context, including the processes, platforms, tools, and infrastructure currently in place at NRC. This is necessary to effectively integrate the proposed digital solutions and optimize data exchange and collaboration both within the NRC and across the network of Canadian built asset industry stakeholders who are involved in the development and use the NRC's key resources.

This section reviews the NRC's current state, focusing on the scope and context of its operations within the Canadian built asset industry. It includes a review of NRC's processes, platforms, and technological capabilities to ensure that they are considered in defining the NRC DCP framework and architecture. More specifically, the NRC's three key resource areas for the Canadian built asset industry, namely the NMS, the CCMC, and the NMCC and the processes underlying their development, use and maintenance are discussed.

3.1. National Model Construction Codes

The Canadian National Model Construction Codes (NMCC) were designed to ensure the performance of buildings, with a specific focus on occupant safety. The codes were first developed in the 1930s, with the first edition published in 1941. The NMCC is comprised of 5 specific codes as shown in the Figure 6. Appendix 3 offers more insight into the NMCC, namely how provincial building codes are developed from the NMCC.

The NMCC is developed, published, and maintained following a structured workflow as shown in Figure 7. The figure shows two starting points whereby one starting point is the development of code content, and the other is the authoring of documents. In either case, the first steps consist in the technical content creation whereby experts are called upon to develop the initial code content. Once developed, the content is edited in English and translated to French (or vice-versa is the document was initially authored in French). The content is then sent for approval. Content is managed in an XML format for easier management and distribution. After initial authoring and review, an initial draft of a specific document is assembled, and reviewed for completeness and formatting. Should they be required, corrections are made at this point. Finally, a draft PDF is created, reviewed by editors and technical experts, and finalized for publication in print and electronic formats.

Figure 6 Overview of Canadian Model Building Code

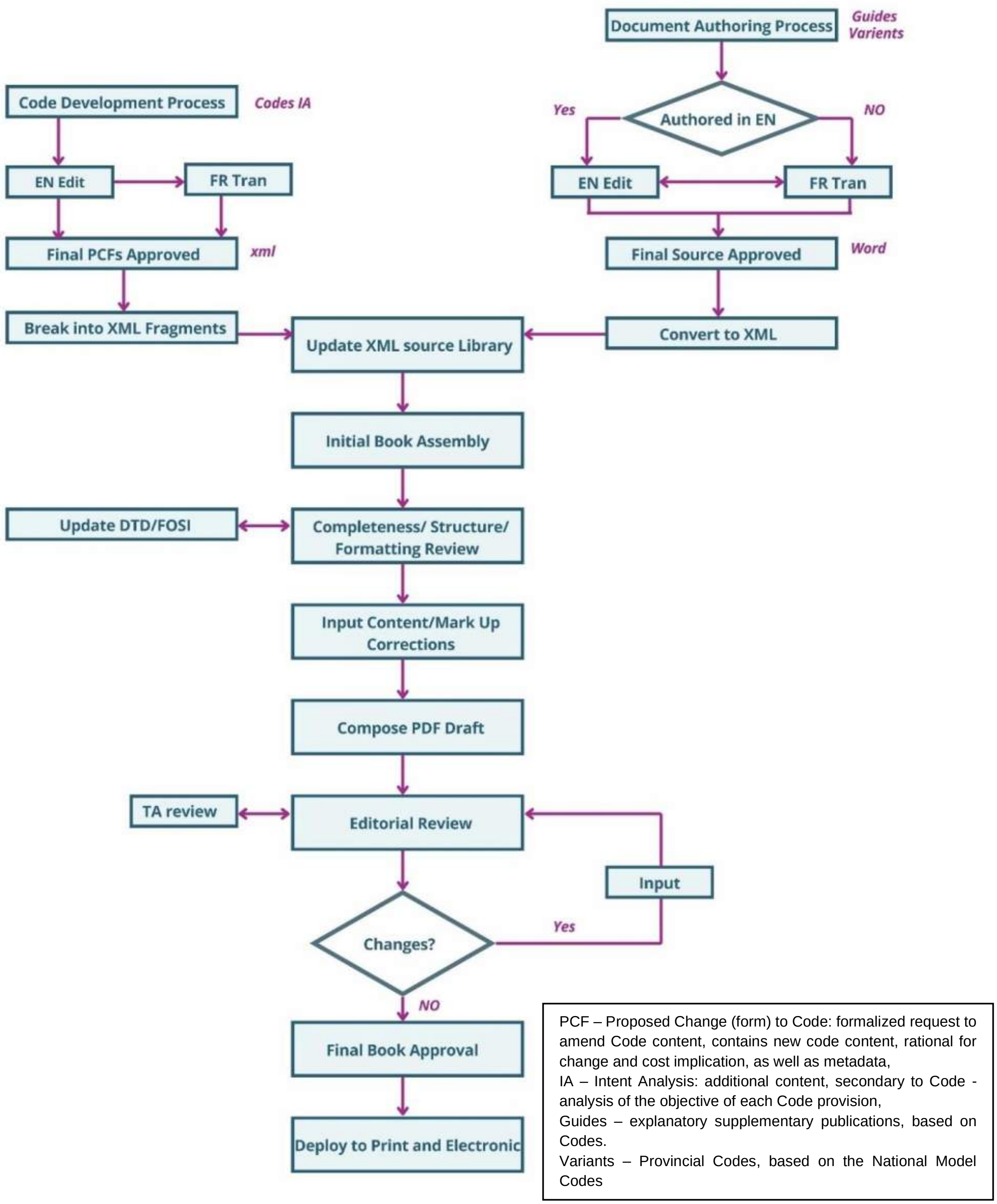


Figure 7 The NMCC development process (Adapted from NRC, 2023)

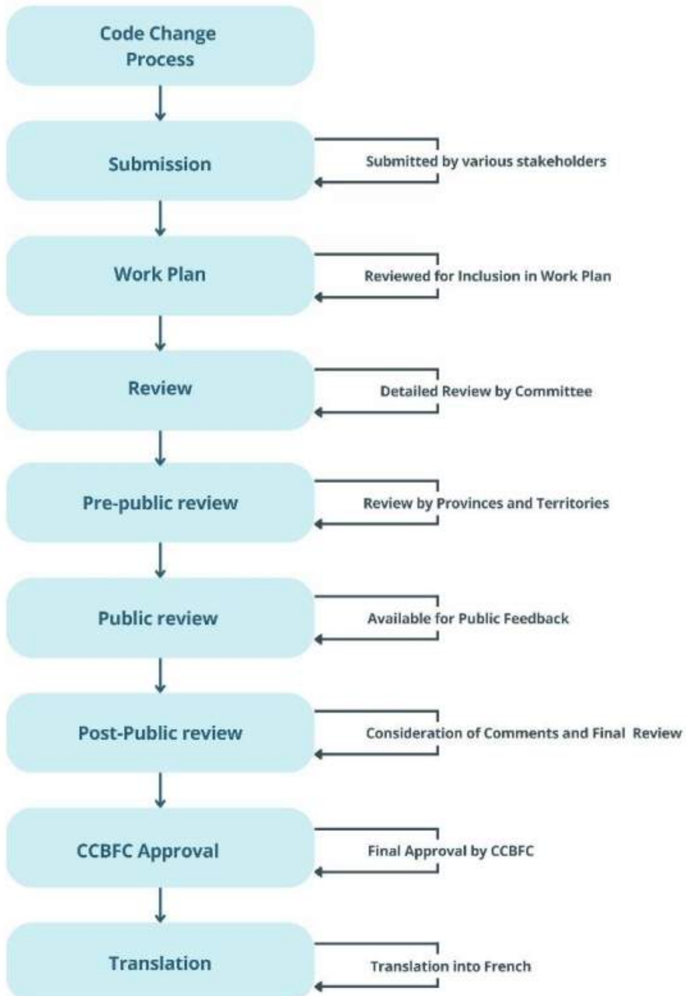


Figure 8 The NMCC Code Change Process

Codes are generally reviewed and updated every 5 years. Figure 8 outlines the process for updating the NMCC. Revisions and updates are generally proposed by stakeholders who submit proposals for code updates. Proposals are reviewed, and if accepted, are incorporated into a work plan that is subsequently evaluated by a committee.

Based on the review of the NMCC, several key considerations and challenges were identified to be addressed through the NRC DCP project. These considerations and challenges are furthered explained in section 3.5. Essentially, the iterative review and update process, including addressing public input, comparing regional codes, responding to user inquiries, ensuring that the codes remain relevant, accurate, and helpful for everyone involved in building and fire safety is paramount. This process requires facilitation to ensure its effectiveness and efficiency.

3.2. The NMS

The NMS is a comprehensive resource for construction project specifications, featuring a library of master specifications that has been continuously updated for over 35 years. The NMS covers over 780 specification sections, available both in English and in French. Each specification section is organized by construction type to facilitate navigation and is accessible in various electronic formats, principally for word processing software.

The NMS provides many benefits to Canadian built asset industry stakeholders, namely by providing a consistent and comprehensive framework for clear communication of requirements relating to building products and systems, namely through classification leveraging MasterFormat™ and UniFormat™ classification systems. In this sense, the NMS covers a wide range of construction products, materials, and practices, promoting sustainable building and reflecting current industry standards. Finally, the NMS offers both prescriptive (detailed) and performance-based specifications to accommodate various project needs.

The NMS is managed and updated by the NRC in collaboration with industry experts, as shown in Figure 9. The NMS is reviewed and updated quarterly to reflect the latest technological advancements, evolving materials and installation methods, market trends, as well as industry best practices. Three key committees are involved in the review and update process. The NMS National Advisory Board provides direction, establishing goals and priorities for the NMS development process. The NMS technical committee is comprised of representatives from industry and professional associations and advises on technical content of the NMS, ensuring the technical accuracy and practical application of NMS content. Finally, the NMS technical teams are the dedicated task groups that perform the updates and changes to the NMS itself.

Based on the review of the NMS, a number of key considerations and challenges were identified to be addressed through the NRC DCP project. Similarly to the NMCC, the iterative review and update process, including addressing public input, responding to user inquiries, ensuring that the specifications remain relevant, accurate, and helpful for everyone involved in the building process is paramount. This process requires facilitation to ensure its effectiveness and efficiency. The specific considerations and requirements are discussed in section 3.5.

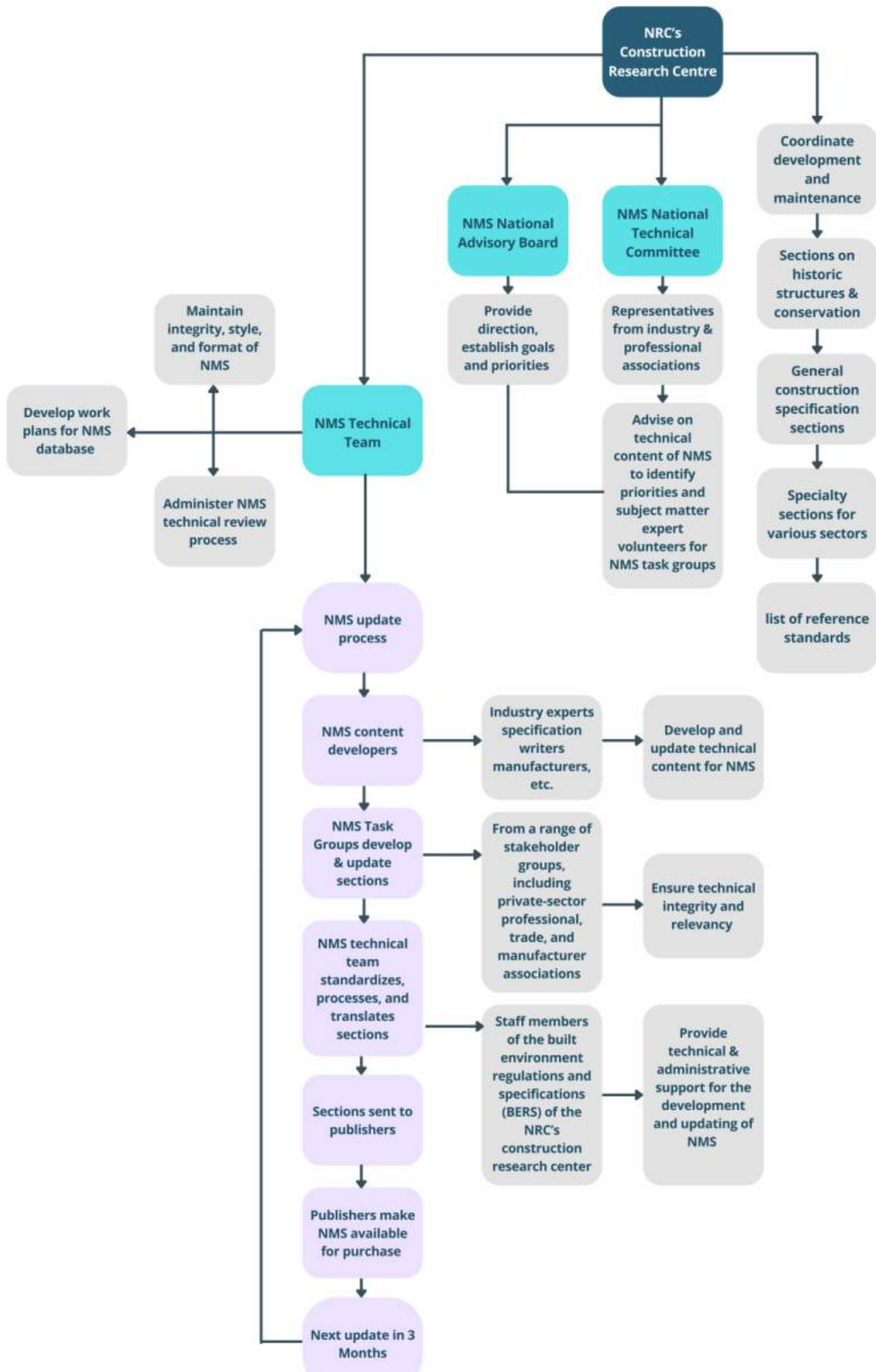


Figure 9 Overall NMS development process within the NRC's Construction Research Centre (Adopted from NRC,2024)

3.3. The CCMC

The NRC's Canadian Construction Materials Centre (CCMC) assesses construction products for compliance with Canadian building, energy, and safety codes. It also publishes technical information on construction product compliance with national and provincial codes on the NRC's website. The CCMC plays a crucial role in ensuring product safety, fostering innovation, and maintaining adherence to regulations within the construction industry. Indeed, assessments performed by CCMC are trusted by regulators across Canada as evidence of code compliance (subject to limitations). In this light, the CCMC is actively engaged with provincial building authorities. It is important to note that CCMC assessments address code compliance and not all project-specific regulations. Users remain responsible for ensuring overall compliance. Moreover, project-specific acceptance may be possible through collaboration with the Authority Having Jurisdiction (AHJ) and qualified professionals but isn't guaranteed.

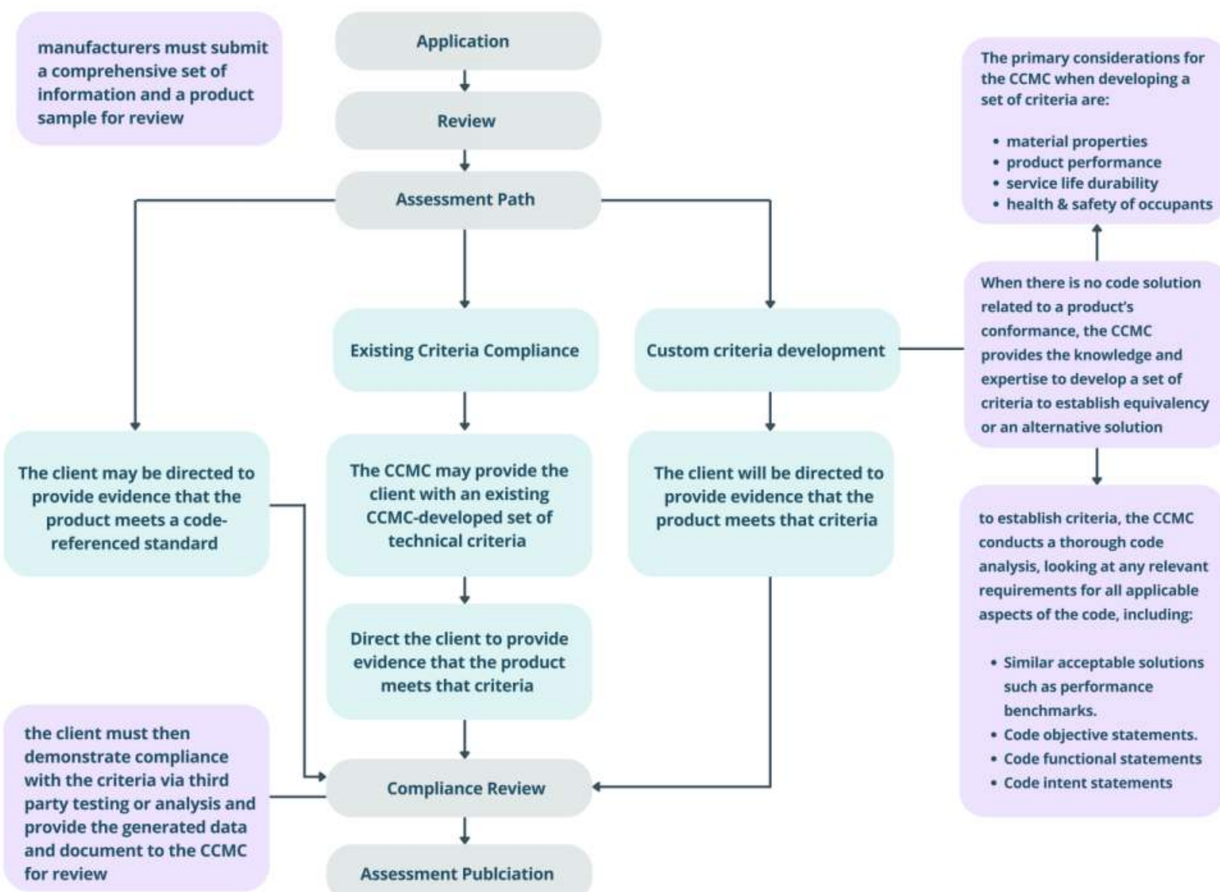


Figure 10 CCMC technical assessments of construction products process (Adopted from NRC,2024)

Product assessments by CCMC follow a structured process to ensure impartiality and thorough evaluation. Figure 10 illustrates this process, detailing the steps involved in assessing and validating construction products to ensure they meet the necessary standards and regulations.

The first step is the application for assessment by a manufacturer. Manufacturers submit detailed information about their product, including its intended use, installation methods, and a sample for review. Upon application, the CCMC analysts perform a review and determine the type of assessment path to be undertaken. They may consult with experts for more complex products. There are three different paths available for assessment: (1) a product or material meets an existing code-referenced standard, (2) through demonstrating compliance with existing CCMC criteria, or (3) by developing custom criteria with the CCMC (for innovative products). Depending on the chosen path, the manufacturer provides evidence that their product meets the established criteria. This may involve third-party testing or analysis. Finally, the CCMC publishes the assessment results in their online registry, providing validation for manufacturers as it pertains to the suitability of their product in meeting code and other regulatory requirements.

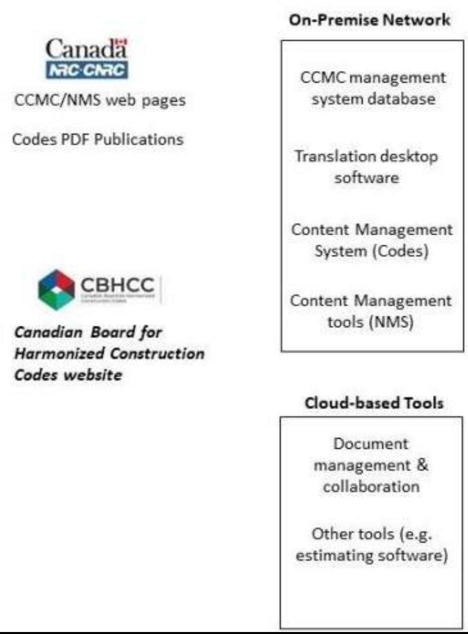
The CCMC assessment process ensures that evaluated construction products conform to specified requirements, thereby promoting consumer and industry confidence while facilitating trade. The assessment is an objective, evidence-based evaluation or certification process conducted by the CCMC as an impartial third party on behalf of the Government of Canada. The assessment confirms that the product conforms to a relevant standard or national/provincial/territorial code(s) for its intended function(s) when installed according to the CCMC-approved installation requirements. Only fully developed products or finalized prototypes are eligible. Additionally, a quality management system, an installation manual, product labels, and technical data sheets as well as a representative product sample must be made available for review. Overall, the CCMC plays a critical role in ensuring the safety, innovation, and code compliance of construction products in Canada. The comprehensive assessment process serves as a trusted mechanism for manufacturers to demonstrate product quality, while providing regulators and industry stakeholders confidence in the safety and performance of construction materials.

Based on the review of the CCMC, several key considerations and challenges were identified to be addressed through the NRC DCP project. Essentially, the building permit application and review process require facilitation to ensure its effectiveness and efficiency, especially as it relates to submittals and documentation. Moreover, making product data available to a broad number of Canadian built asset industry stakeholders in multiple formats is paramount. Linking this product data to specifications and the NMCC can also potentially be of high value, especially in the context of decarbonizing the Canadian built environment. The specific considerations and requirements are discussed in section 3.5.

3.4. NRC’s IT Infrastructure, Platforms & Applications

In parallel to the NRC’s three key resource areas for the built asset industry and considerations for their digitalization, this research project focusses on the NRC’s current information systems, IT platforms and software tools. The objective is to delineate the frameworks, platforms, and tools currently in use, examining their roles and functionalities in supporting NRC's strategic initiatives to better inform the development of the NRC DCP and to ensure that it is suitable for the NRC’s operational context.

The current IT infrastructure of the NRC (Figure 11) is comprised of on-premise network systems and cloud-based tools, each playing distinct roles in managing the organization's data and content. The on-premise network houses systems such as the CCMC management system database, content management systems for Codes and NMS, and desktop translation software. These systems are integral to the secure and efficient handling of data and content related to Canada’s construction codes and standards. On the other hand, cloud-based tools are employed for document management, collaboration, and other specialized functions like estimating software. Additionally, the NRC maintains multiple web pages and publication platforms, including the CCMC/NMS web pages, Codes PDF publications, and the Canadian Board for Harmonized Construction Codes website, which serve as key interfaces for stakeholders accessing critical information. This dual approach in IT infrastructure reflects a blend of legacy systems and modern cloud solutions, highlighting the NRC's transition towards more flexible and collaborative digital tools while still relying on robust on-premise systems for critical operations.



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Content and Workflow Management

The NRC employs a range of systems for content and workflow management. The NMCCs are managed with an in-house Content Management System (CMS), which supports NMCC processes for the Canadian Board for Harmonized Construction Codes, such as Code Change Requests, Public Reviews, and publication. Content is managed in XML format.

NMS content is managed in multiple formats (XML, relational & unstructured data) for various processes and use cases. NMS content is published on NRC's website and through third parties who offer specification writing and related tools.

CCMC product information and associated workflows are managed in a relational database.

Data Integration and Storage

Currently, Codes, NMS, and CCMC content management systems and data storage generally reside on on-premise servers and networks. Integration between systems or with external applications or data sets are limited. However, the cloud infrastructure and platforms being developed through the IT modernization project will enhance data integration capabilities. Specifically, this will improve connections between Codes, CCMC and NMS and will provide API management capabilities to link with external datasets and tools, such as the Building Smart Data Dictionary, third-party reference standards data, and other relevant external resources.

IT Modernization

The NRC is currently undergoing a transformative IT modernization project to enhance the management and accessibility of its Codes, the CCMC evaluations, and NMS that is in line with its overall objectives for the DCP. This initiative aims to streamline content management, enhance workflow efficiency, and improve integration capabilities, ensuring that NRC remains at the forefront of delivering high-quality codes and standards to the Canadian construction industry. The proposed system architecture is shown in Figure 12.

The Codes, NMS, and CCMC teams are actively modernizing their IT systems to enhance content management, workflow processes, and collaboration capabilities. This initiative will include the implementation of a modern Component Content Management System (CCMS) supporting the Darwin Information Typing Architecture (DITA) standard to facilitate content re-use and improving unification of Codes, NMS, and CCMC content sets with the ability to configure additional output types, such as web-accessible HTML and machine-readable formats.

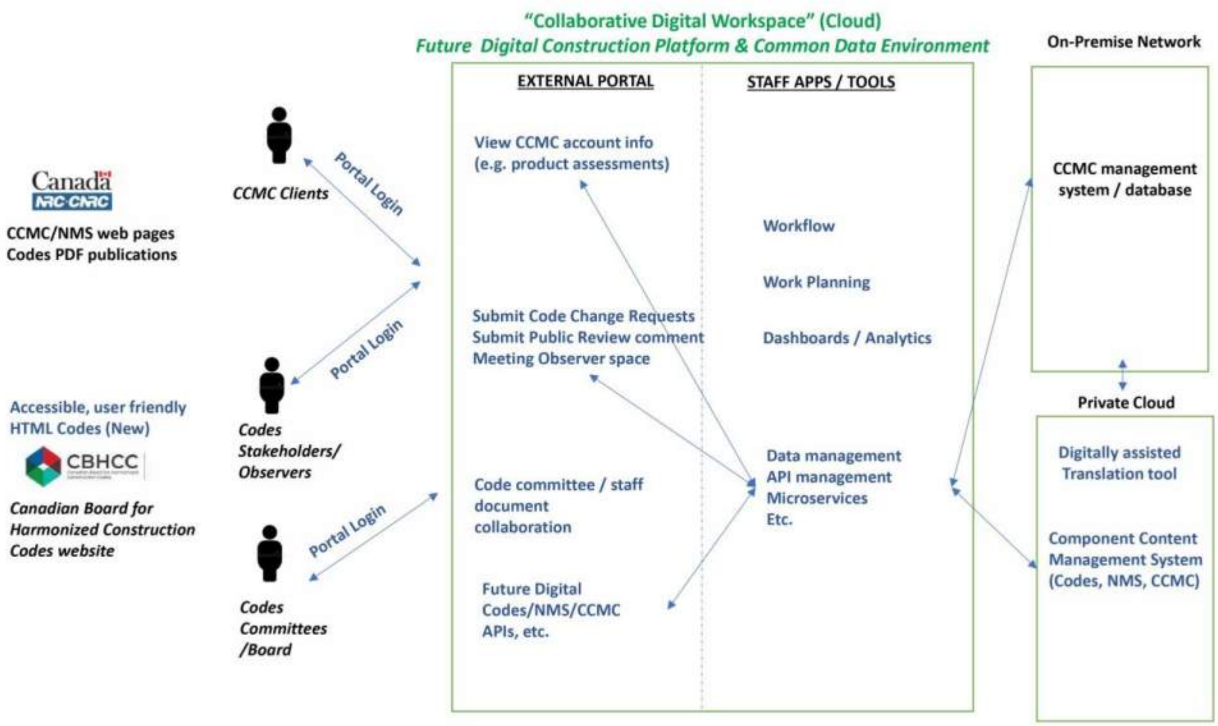

Figure 12 NRC's IT Modernization initiative - work in progress (Provided by NRC)

The IT modernization project will also include a new portal for CCMC clients and Codes committees and stakeholders, a web tool for viewing Provincial/Territorial variations to the NMCC, planning tools and dashboard to track Codes development tasks, Code Change Requests, Proposed Change Forms and Public Review comments, and integration of a translation system with the CCMS and other process/workflow applications. The development of components such as microservices, integrations, and data management / data analytics are also considered and are aligned with the DCP initiative.

It is anticipated that the new collaboration portal, tools, content system and cloud platforms that are deployed through the IT modernization project, will be enhanced or extended to support future state content digitalization and CDE capabilities, and form the basis for the NRC DCP. Additionally, low carbon or Lifecycle Assessment tools, data or content arising from the NRC Platform to Decarbonize the Construction Sector at Scale, may leverage this new cloud ecosystem, enabling centralized management of LCBE and CSDP program outputs, and potential data integrations such as BIM-LCA.

3.5. Considerations from the Current State Review

The current state review process involved several research activities including interviews and workshops as well as documents reviews. In reviewing the current state of the NRC digital code and product resources, several key limitations and issues were identified. These challenges underscore the necessity for a more efficient, harmonized, and secure digital platform capable of managing the complexities of building codes, regulations, and product specifications while addressing the needs of a diverse group of stakeholders.

The review revealed that the NRC's current digital resources are hindered by issues related to data complexity and volume, lack of uniformity, interoperability challenges, and technical infrastructure limitations. Additionally, concerns were identified regarding the accuracy and consistency of data, the allocation of resources, and the need for improved stakeholder engagement and regulatory compliance. Addressing these factors is essential to ensure that the NRC's DCP can support the evolving demands of the industry and provide a robust platform for the future. The following considerations, which stem from the current state analysis, are highlighted to inform the NRC DCP project moving forward.

Data Complexity and Volume:

- **Complexity**: Building codes and regulations as well as product specifications and data are often highly detailed and complex, requiring careful interpretation to ensure accuracy. Interdependencies between clauses require understanding and proper consideration.
- **Volume**: There is a large volume of information that requires digitization across all three resources, which can be time-consuming and resource intensive. While some of this content is already digitized and available in various formats, such as xml, it is not necessarily machine readable and/or suitable for computation.

Requirement: The NRC DCP must be able to contend with this complexity and large volume of data and information in a simplified and efficient manner. It must provide capabilities to link important data sets between the three resources in the cases where such links are necessary to support a specific purpose (e.g., product data linked to a specification section in response to a code provision).

Uniformity, harmonization, and interoperability of content:

- **Lack of Uniformity:**
  - (NMCC) Building codes can vary significantly across different jurisdictions, making it challenging to create standardized digital formats.

- The lack of harmonization and clarity in product data information (CCMC) makes it difficult to grasp, especially when determining which properties are necessary for specific use cases or validation types. Understanding these requirements can be quite challenging.

- **Interoperability**: Digital resources may not be compatible across various software and platforms used by architects, engineers, and construction professionals.
- **Alignment and harmonization**
    - (NMCC) Technical differences between regional codes and the NMCC must be analyzed to achieve greater consistency across jurisdictions.
    - (CCMC) Properties and attribute naming, units, and other product data types may not be consistent between manufacturers, regions, etc.

Requirement: The NRC DCP must facilitate this uniformity, harmonization, and interoperability of all NRC content.

Accuracy and consistency of content:

- **Error Minimization**: The content development process potentially introduces errors or omissions that could lead to misinterpretations.
- **Consistency**: An ongoing concern is maintaining data consistency to avoid discrepancies that could impact compliance and enforcement.

Requirement: The NRC DCP must allow for consistency and support the elimination of redundancies and errors in the process.

Cost and Resource Allocation:

- **Financial Investment**: Financial resources are required to support the digitization process, including software development, data entry, and quality assurance.
- **Human Resources**: Skilled personnel are needed to oversee the digitization, ensure accuracy, and maintain the digital systems.

Requirement: The deployment of the NRC DCP will require robust training programs and guidance for all stakeholders involved.

Technical Infrastructure:

- **Distributed Digital Platforms**: A significant challenge lies in developing and maintaining robust digital platforms that can effectively manage data while providing user-friendly interfaces for accessing and utilizing the codes.

- **Cybersecurity**: Protecting sensitive data from cyber threats and ensuring secure access to the digital codes and regulations.

Requirement: The NRC DCP must allow for the integration of existing infrastructure where applicable and support the deployment of robust cybersecurity measures.

Stakeholder Engagement:

- **Collaboration**: Engaging with a wide range of stakeholders, including government agencies, industry professionals, and software developers is required to ensure that resources meet the needs of all users.
- **Effectively address public input**:
  - (NMCC; NMS) Public review process should be intuitive and straightforward. Moreover, proposed changes following a public review process requires tracking.
- **Training and Support**: Providing adequate training and support to users, facilitating the transition to digital codes, and ensuring they can effectively utilize the new systems.
- **Facilitate responses to code enquiries**: There is a need to address user inquiries and feedback to ensure clarity and provide support for users.

Requirement: The NRC DCP should support engagement and provide mechanisms for feedback from relevant stakeholders.

Regulatory Compliance:

- **Legal Considerations**: Ensuring that the codes comply with existing legal frameworks and standards.
- **Updates and maintenance**: Keeping the digital codes up to date with any changes in regulations while ensuring that updates are promptly implemented and effectively communicated to users.

Requirement: The NRC DCP should facilitate integration with diverse information sources and enable efficient tracking of relationships among these sources.

4. Towards the NRC's Digital Construction Platform

The NRC's DCP aims to digitalize processes and offer services to Canadian built asset industry stakeholders by providing standardized frameworks to facilitate desired outcomes and identify essential services and resources to support them. The NRC DCP supports the achievement of the NRC's PDCSS, whose overarching objective is to enable the digitalization of the Canadian built asset industry to improve productivity and support its decarbonization. More specifically, with the DCP, NRC's Internal Strategic Objectives are to:

- Structure and centralize the content development and curation efforts for NRC resources, including CCMC, NMCC, and NMS.
- Enable consolidation of the resources required to support these developments.
- Streamline collaboration across NRC's departments.
- Facilitate dissemination of NRC resources.
- Provide avenues for future NRC services and product offerings.

In parallel, NRC's External Strategic Objectives with the DCP are to:

- Provide resources and services to enable the digitalization of the Canadian built asset industry, enhancing productivity and decarbonization.
- Support standardization and harmonization of digital practices across the Canadian built asset industry.
- Create opportunities to develop and expand service offerings by leveraging NRC resources.

The DCP will benefit multiple stakeholder groups, including NRC, Government agencies, and Canadian built asset industry stakeholders. For NRC specifically, the DCP offers standardized methodologies for resource development, enhancing consistency and efficiency in the creation of these resources. It will also provide centralized repositories to improve accessibility and management of resources. Lastly, it will enable the establishment of common language and harmonized processes to foster better communication and collaboration across NRC departments. For Government Agencies, the DCP offers a common resource framework that will enable the implementation of harmonized practices within the construction industry, while providing tools and technologies to facilitate advanced information modelling techniques and strategies. Furthermore, the DCP aims to enhance regulatory efficiency by offering streamlined code compliance checking capabilities and digital permitting processes, leveraging NMCC resources. Finally, CCMC resources made accessible through the DCP will facilitate advanced use and analysis of governmental built assets, including lifecycle assessment (LCA) and carbon reporting.

For Canadian Built Asset Industry Stakeholders, the DCP will provide access to useful resources that enhance their productivity and efficiency through digitalization. The DCP will support promotion of common and harmonized approaches for seamless digital workflows across the industry. NRC resources made available through the DCP will greatly benefit the Canadian built asset industry. For instance, NMCC resources will reduce administrative burden and accelerate project timelines through automated code checking and digital permitting, whereas CCMC resources will facilitate advanced use and analysis of built assets, supporting sustainability goals. Finally, NMS resources will ensure accuracy and consistency in project requirements through automated specification development.

It is expected that all stakeholders operating within the Canadian built asset industry, including government agencies, professionals (architects, engineers, etc.), construction companies, manufacturers, and regulatory bodies be positively impacted by this effort. As the DCP is developed, it is expected that many of the NRC's departments, government agencies, industry stakeholders, and other relevant entities involved in the construction and decarbonization processes will be involved throughout the delivery of the DCP.

4.1. Target State for the NRC DCP

The envisioned target state for the NRC DCP is a functional platform that:

- Is broadly used and referenced by all stakeholders.
- Promotes effective communication and training.
- Fulfills multiple needs for various stakeholders through modularity and scalability.
- Provides a common and harmonized way of working through established standards.
- Offers flexibility in the use of digital workflows, tools, and technologies, facilitated by a robust architecture.
- Remains open and neutral, enabling interoperability across domains, systems, and resources.
- Facilitates integration and connections with existing platforms and tools.
- Supports seamless information exchanges between various stakeholders in the Canadian built asset industry, with a focus on governmental actors across all three layers of government.
- Enables NRC to author content and make it available in an intuitive and standardized way.

To reach this target state, the NRC's DCP framework is organized into three distinct tiers, each pivotal in managing and leveraging data within the NRC Digital Construction Platform (Figure 13). These tiers comprehensively address key aspects of data management and utilization, laying the foundation for effective digital transformation and enhanced interoperability across the built asset industry.

Tier 1: Data Structures / Data Models – Tier 1 establishes a Common Data Framework (CDF) for the Canadian built asset industry. It encompasses essential components such as syntax, semantics, concepts, processes and workflows, practices and methodologies, and services. The goal is to ensure robust and coherent data organization that promotes interoperability across various dimensions of the built asset industry and its digitalization. By adopting standardized resources and practices, this tier lays the foundation for consistent data management and seamless integration of information. As such, it not only lays the foundation for the development of the DCP, but also for the development of platforms by other interested parties utilizing common resources.

Tier 2: Data Exchange / Data Acquisition – Tier 2 focuses on the development and implementation of the NRC Digital Construction Platform (DCP), ensuring its seamless integration with various Common Data Environments (CDEs) and services. This tier aims to create a functional, interoperable, and scalable platform that supports the diverse needs of stakeholders in the Canadian built asset industry. Emphasizing seamless communication and interoperability, it facilitates the integration of data across different platforms and systems. While this tier primarily targets NRC's platform, it is designed to benefit other governmental or NGO platforms by leveraging the common data framework established in Tier 1. However, the exploration of these potential integrations is beyond the scope of our current work.

Tier 3: Data Processing / Data Consumption - Tier 3 of the NRC DCP framework addresses the processing and consumption of data, emphasizing digital codes and e-permitting processes, as well as analytical processes like Life Cycle Assessment (LCA). This tier leverages standardized data structures from Tier 1 and efficient data exchange protocols and platforms from Tier 2 to facilitate comprehensive and accurate data analysis and decision-making. The integration of advanced data processing and analytics tools, robust data visualization and reporting methods, and stringent data quality and validation standards ensures the effective utilization of data. Although LCA is acknowledged as a key use case, it may not be explored in depth within the scope of the current project. Other services can be delivered on the basis of the DCP framework, namely digital twin services, which are also out of the scope of this project.

Each tier is integral to the overall functionality and success of NRC's digital platform, promoting a unified and efficient approach to the Canadian construction data management.

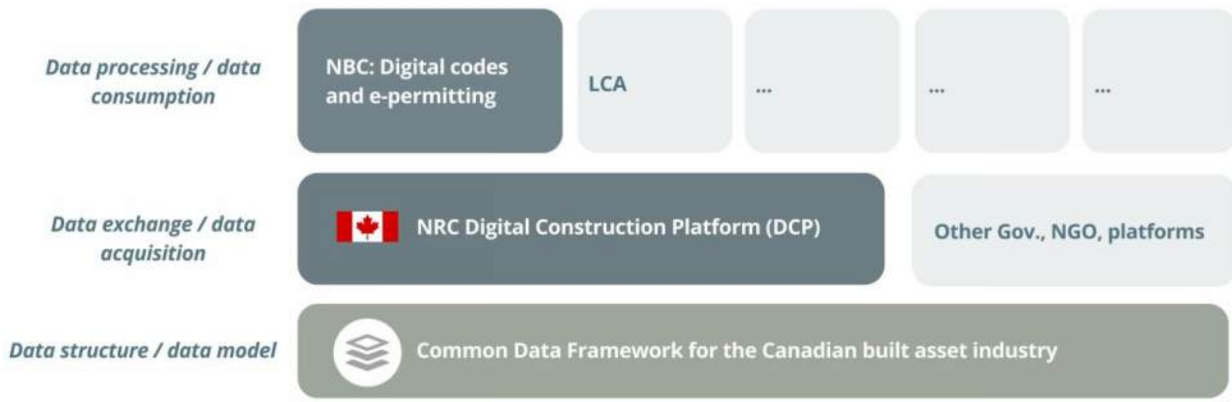

Figure 13 NRC's Digital Construction Platform layered framework

4.2. Tier 1 - The Common Data Framework for the Canadian Built Asset Industry

The CDF defines and structures the key resources required to enable connectivity and interoperability across the built asset industry's domains and dimensions (Poirier et al., 2014). These resources encompass six key domains: semantics, syntax, concepts, processes, practices, and services, each defined and structured to facilitate comprehensive integration and efficiency (Figure 14).

Semantics, Syntax, and Concepts create the foundations, ensuring data is consistently defined, organized, and modelled. Building on this base, Processes & Workflows, along with Practices & Methodologies, ensure that the data is not only applied effectively but also managed according to industry standards while maintaining security. Services play a pivotal role; they offer the necessary tools for users to engage with this well structured, standardized, and secure data in real time. This ensures that the CDF transitions from a theoretical framework to a practical solution, ready for real-world applications. Table 3 shows how these domains in CDF interact with each other.

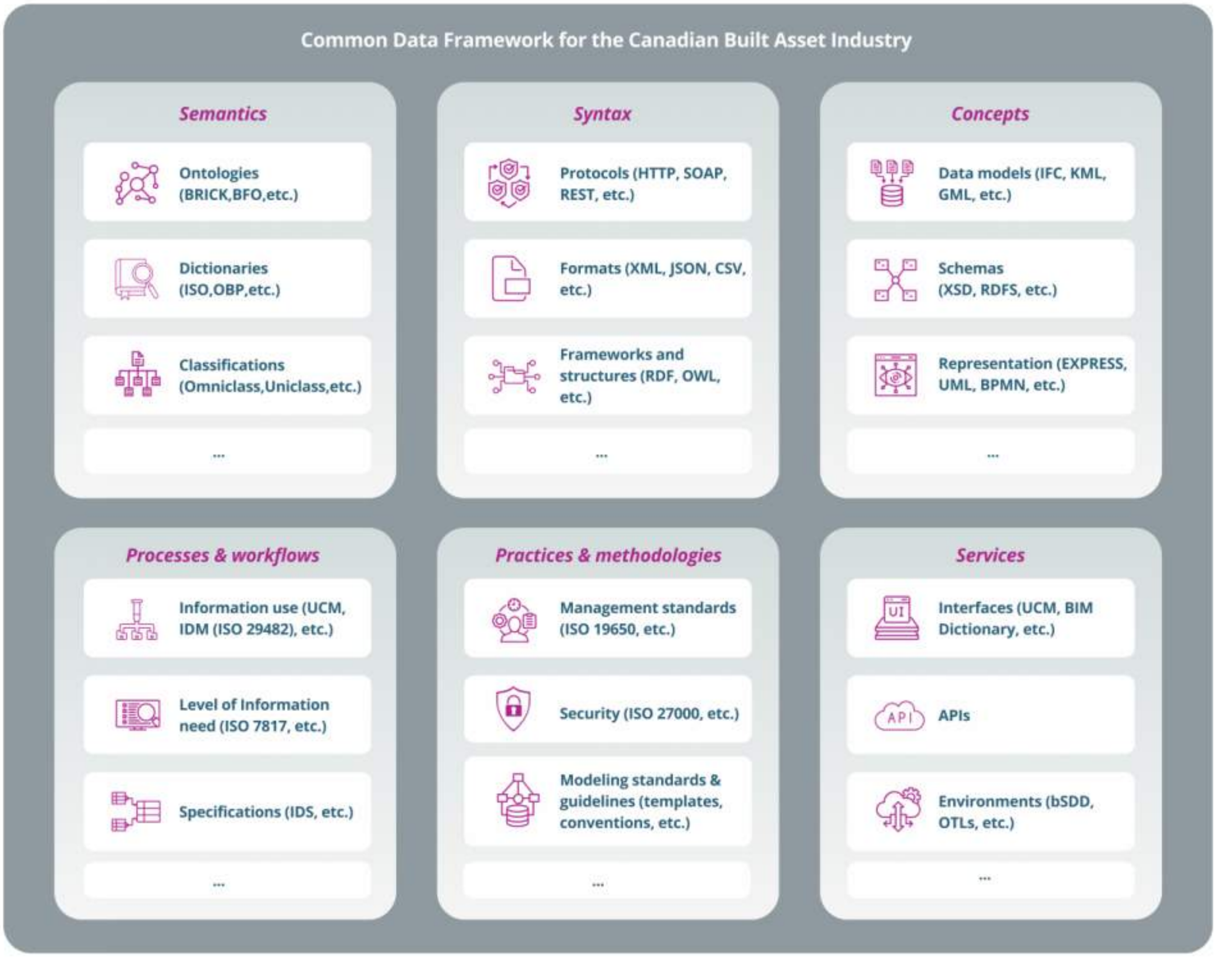

Figure 14 Common Data Framework for the Canadian built asset industry

Table 3 CDF's domain interactions

Domain	Interacts With	Description of Interaction
Semantics	Syntax	Ensures that the structure defined by syntax is populated using meaningful and standardized terminology.
	Concepts	Underpins data models by ensuring terms and classifications are consistent and standardized.
	Processes & Workflows	Defines the level of detail and categorization needed in workflows, ensuring accurate interpretation.
	Practices & Methodologies	Helps apply policies and management practices consistently, using the correct terminologies.
	Services	Ensures that data exchanged or accessed through interfaces and APIs remains accurate and interpretable.
Syntax	Concepts	Supports data models and schemas by providing necessary formats and protocols for standardized applications.
	Processes & Workflows	Defines how data is shared within workflows, using the correct protocols and formats.
	Practices & Methodologies	Ensures that data exchange follows industry protocols, maintaining data integrity and security.
	Services	Underpins the technical operations of Services, ensuring APIs and interfaces follow standardized formats.
Concepts	Processes & Workflows	Guides data modelling and representation within workflows to ensure relevant and properly structured data.
	Practices & Methodologies	Ensures consistent and compliant implementation of data models and schemas in data management.
	Services	Ensures that interfaces and APIs apply data models and representations effectively for user interaction.
Processes & Workflows	Practices & Methodologies	Formalizes modelling, exchange and management and security practices to ensure data handling complies with industry regulations and standards
	Services	Provides necessary data at the right time and format to ensure accessibility and usability by stakeholders.
Practices & Methodologies	Services	Incorporates management standards and security practices into the operation of interfaces, APIs, and other services.

By establishing a robust and coherent data organization, the CDF ensures that all stakeholders can communicate effectively, reducing miscommunication and errors while promoting consistency and accuracy in data management and utilization. Previous research in this area, including the DigiPlace project, work by Mirarchi et al. (2021), and initiatives by the Centre for Digital Built Britain (CDBB), can serve to further inform and frame the CDF.

4.2.1. Semantics

The coherent and widespread use of standardized vocabulary is necessary to ensure clear and consistent information exchange as well as resource reuse. Semantics deal with language, meaning, and its context. According to ISO/IEC 11179-5:2015 (4.27), semantics is the "branch of linguistic science that deals with the meanings of words" and ISO/IEC TR 24800-1:2012 (2.5) defines them as the "mapping between elements of a language and the real world. Semantic interoperability enables systems, whether human or machine, to exchange data, information, and services by ensuring that all actors within the interacting systems share the same meanings for the same terminology (Heiler, 1995). In the context of the proposed CDF, semantics is primarily structured through ontologies, dictionaries, and classifications.

Ontologies are defined as a "specification of concrete or abstract things and the relationships among them in a prescribed domain of knowledge" (ISO 19763-9, 2015). They are developed to define a common vocabulary that describes data and their relationships, enabling consistency in interpretation by various actors in and across systems. The intent is to eliminate ambiguity regarding the use of a term or concept in a particular setting. Numerous ontologies for the built environment and the built asset industry have been developed over the years to cover parts of the domain, including specifications, materials, and codes, as well as detailed ontologies for practices such as costing, scheduling and planning, LCA, and the application of Circular Economy (CE) principles. Additionally, several high-level ontologies are general in nature and are used to convey meaning and context around general terms and concepts not necessarily related to the built environment but required to support digital transactions and exchanges (Menzel et al., 2022).

Dictionaries are defined as a "list of words or a category of words from a language arranged alphabetically or systematically and explained in that language or translated into one or more other languages." (ISO/IEC 15944-7, 2009). They provide precise definitions, ensuring consistency and accuracy in the terminology used throughout the built asset industry. Dictionaries can also include lists and repositories of resources to be (re)used in different contexts. Dictionaries can refer to either or both the content (the terms and their definitions) and the container (the service hosting the content – see Services).

Classification is the "process of assigning objects to classes according to criteria" (ISO 22274, 2013). In this regard, ISO 12006-2 provides a standardized framework for classifications in the built asset industry and recommends titles for classes of information objects (ISO, 2015). **Taxonomies** also categorize terms relating to the built environment according to their characteristics (space, product, material, safety terms, etc.).

Ontologies, dictionaries, and classifications are intricately connected, forming the backbone of the semantic structure within the CDF. Ontologies establish the framework for comprehending the relationships between concepts, while dictionaries ensure that the terms within these frameworks are precisely defined. Classifications then organize this information into accessible categories. In practice, these components work together seamlessly to achieve semantic interoperability.

Recommendations for NRC CDF

Appendix 4 presents a subset of semantic resources available for the built asset industry, focusing on specifications, materials, and codes. Further refinement and prioritization of these resources will be necessary to align with NRC priorities and requirements. The development of specific ontologies may become necessary during NRC projects and should be anticipated. Concurrently, the buildingSMART Data Dictionary (bSDD) can be adopted as a valuable standardized reference library for terminology and classifications, contributing to the overall consistency and integration of semantic resources. Although bSDD is not an ontology, it serves as a crucial framework for standardizing terminology across different systems and stakeholders within the built environment. To further enhance this framework, NRC could consider implementing a Dynamic Ontology Management System to ensure continuous updates and refinements as industry standards evolve.

4.2.2. Syntax

Syntax pertains to the structured representation and format used to define and describe elements within digital models and documentation. It encompasses a "set of rules that govern whether a sentence (or other units of communication) is well formed" (ISO/IEC TR 24800-1:2012, art. 2.6). In the context of digitalization within the built asset industry, ensuring that data transactions adhere to agreed-upon rules, such as data formats or communication protocols, is crucial to achieving interoperability and compatibility across different technologies and systems. Within the proposed CDF, syntax is supported by protocols, formats, frameworks and structures.

Protocols are "convention[s] that define the syntax, semantics, and synchronization of the communication process between [actors in a system] in order to enable a particular service" (ISO 25964-2, 2013). They are constituted by sets of rules and conventions that define how data is formatted and exchanged, ensuring accurate transmission and interpretation across different actors within a system. With the emergence of the Internet-of-Things (IoT), IoT-specific communication protocols like CoAP (Constrained Application Protocol) have been developed for smart building integrations.

Formats, specifically data formats, prescribe "the arrangement of data on a data medium" (ISO 5127, 2017), thereby specifying the structure of data exchanges. Common formats in the built asset industry include open formats like XML, JSON, CSV, as well as proprietary formats. Many specialized formats exist such as GeoJSON which helps enhance location-based services in construction projects.

Frameworks are "logical structures for classifying and organising complex information (ISO/TR 13054, 2012), while **Structures** delineate interrelated components within complex entities, and the relationships between them (ISO 10303-2, 2024). In the context of digitalization of the built asset industry, frameworks and structures play a crucial role in organizing information within databases, utilizing resources such as Resource Description Framework (RDF) or Web Ontology Language (OWL). In support of a modular and extensible approach to the DCP, microservices architectures, such as those defined in ISO/IEC 42010: Systems and software engineering — Architecture description, can be of interest. Furthermore, as referenced above, the IoT domain has developed its own frameworks and architectures, as detailed in ISO/IEC 30141: Internet of Things (IoT) — Reference architecture.

Recommendations for NRC CDF

Protocols, formats, frameworks, and structures are predominantly developed and maintained by specialized third-party organizations. It is advisable for NRC to leverage existing resources rather than developing proprietary ones to ensure syntactic interoperability.

Appendix 4 in this report provides a subset of available syntactic resources relevant to specifications, materials, and codes within the built asset industry.

4.2.3. Concepts

Concepts in the context of digitalization within the built asset industry refer to units of knowledge defined by unique characteristics (ISO 1087-1:2000, 3.2.1). These concepts transcend specific languages but are influenced by social and cultural contexts, which can lead to varying categorizations. To ensure clarity and consistency in information exchange and resource reuse, these concepts must be formalized, structured, and represented uniformly across systems. This alignment is achieved through conceptual and operational models, representation languages, and schemas that facilitate the conveyance of ideas and knowledge within a domain.

Conceptual and **Operational Models**, such as data models, define the structure and relationships within a knowledge domain. In this context, a model is defined as an "abstraction of some aspects of reality" (ISO 19109, 2015), whereas a conceptual model is defined as a "model that defines concepts of a universe of discourse" (*ISO 19101-1:2014)* . A data model is defined as the "description of the organization of data in a manner that reflects an information structure"(ISO 28258, 2013). In the built asset industry, high-level concepts like BIM and GIS are foundational, each with underlying models, with emerging concepts being formalized around smart cities and digital twins such as ISO/IEC 30182 Smart city concept model — Guidance for establishing a model for data interoperability, ISO 23247: Automation systems and integration — Digital twin framework for manufacturing and ISO/IEC 14772: Information technology — Computer graphics and image processing — The Virtual Reality Modelling Language (VRML).

Both BIM and GIS concepts are fundamentally concerned with data, necessitating the development of data models that define the structure and relationships among components within their respective domains. Model-Driven Architecture (MDA) serves as a foundational approach in the GIS domain, emphasizing the creation of schemas at various levels of abstraction as defined in ISO 19103 standards (Figure 15). This includes metamodels, which form the basis for defining other models, abstract conceptual schemas for reusable concepts, conceptual application schemas tailored for specific applications, and implementation schemas designed for databases and exchange formats. In contrast, Industry Foundation Classes (IFC) in the BIM domain, supported by STEP as its underlying architecture and information model, provide a standardized framework but differ from MDA in GIS due to their specific focus on describing building elements and their relationships rather than broader geographic data. This distinction highlights the specialized nature of each approach within their respective domains (ISO/TR 23262:2021, p.6).

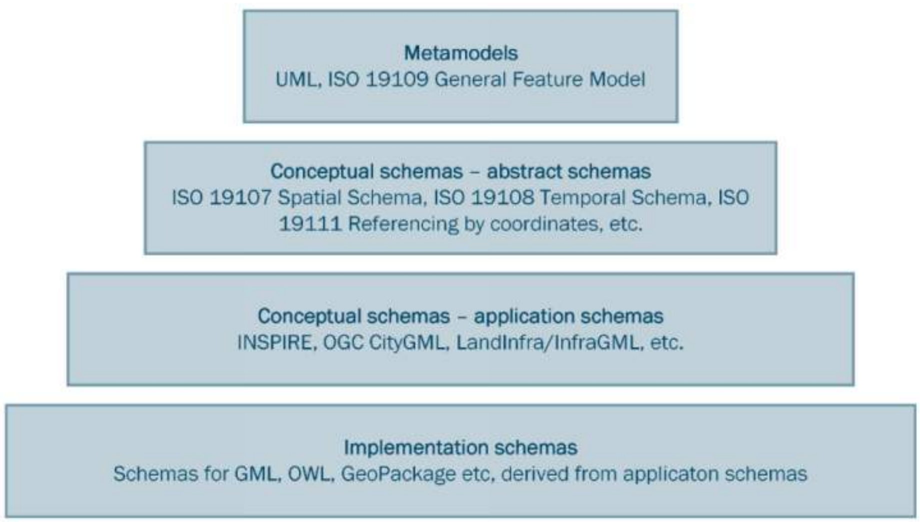

Figure 15 The levels of abstraction in model-driven architecture according to ISO 19103 (Adapted from Jetlund et al. 2019 in ISO/TR 23262)

In the BIM domain, IFC is often misinterpreted as merely a file type. However, IFC encompasses three distinct components: the data model, the data schema, and the data format. As a data model—defined as "the definition of the kinds of data that belong to a particular universe of discourse, including the operations on those kinds of data" (ISO/IEC 9075-2:2023, 3.5.7.)—IFC provides the meaning, context, and structure for concepts within the built asset industry. These concepts are primarily articulated as objects, relationships, and properties. Table 4 outlines the fundamental types for each of these three entities.

Table 4 Fundamental entity types in IFC (Adapted from buildingSMART, 2024)

Objects (IfcObject)	Relationships (IfcRelationship)	Properties (IfcPropertyDefinition)
Products	Assignment	Property and property set template
Processes	Association	
Controls	Decomposition	Property set occurrence
Resources	Definition	
Actors	Connectivity	
Groups	Declaration	

Schemas are "definition[s] of the structure to organize data for storage, exchange and sharing, using a formal language" (ISO 16739-1, 2024). Additionally, a schema is described as a "formal description of a model" (ISO 19101-1:2014, 4.1.34). As previously mentioned, IFC encompasses three aspects: as a data model for the built asset industry, as a data format to facilitate file-based information exchange, and as a data schema that provides a standardized way of describing the built environment.

Figure 16 illustrates an example of the IFC schema for a pump. This diagram highlights a portion of the IFC schema, specifically detailing the structure and interconnections of entities related to a pump type within a building's mechanical systems. The IfcPumpType entity, categorized under the IfcFlowMovingDeviceType, represents a specific type of pump utilized in systems that manage water or air distribution. It inherits attributes like PredefinedType from the **IfcDistributionElementType**, linking it to a broader class of distribution elements. The **IfcDistributionElementType** serves as a general classification that includes all elements responsible for resource distribution, and it connects to the **IfcDistributionFlowElementType,** which further specifies elements that manage the flow of fluids or air. IfcElementType offers a broad categorization for all building elements, while **IfcTypeProduct** and **IfcTypeObject** define the specific physical and object types, detailing their usage and application within the building context. Furthermore, the **IfcRepresentationMap** entity is responsible for the geometric placement of the product, essential for visualizing its location within the digital model. The **IfcObjectDefinition** provides a generalized definition for objects and is linked to **IfcPropertySetDefinition** through HasPropertySets, which includes essential properties like power ratings and maintenance details. The foundational **IfcRoot** entity supplies key attributes such as **GlobalId** and Name for proper identification and documentation, while **IfcOwnerHistory** keeps track of any modifications made to the object.

Other schemas include JSON-LD (JavaScript Object Notation for Linked Data) schemas to enhance the interoperability of web-based data and ISO/IEC 19514:2017 (Systems and software engineering — Object Management Group (OMG) — Systems Modelling Language (SysML)) define standardized data schemas, ensuring data consistency and interoperability.

Representation languages are used to model a knowledge domain or a subset of this domain, illustrating the concepts and their relationships. Many standardized representation formats have been developed to represent various types of domains and knowledge. For instance, Unified Modelling Language (UML) is used for system design, Business Process Model and Notation (BPMN) for business processes, EXPRESS for product data, and Integrated Definition Methods (IDEF) for organizations and systems. In the context of the NRC Digital Construction Platform (DCP), UML, BPMN, and IDEF are likely to be the most useful. However, other representation formats may also be relevant to investigate and implement depending on the project's evolving requirements.

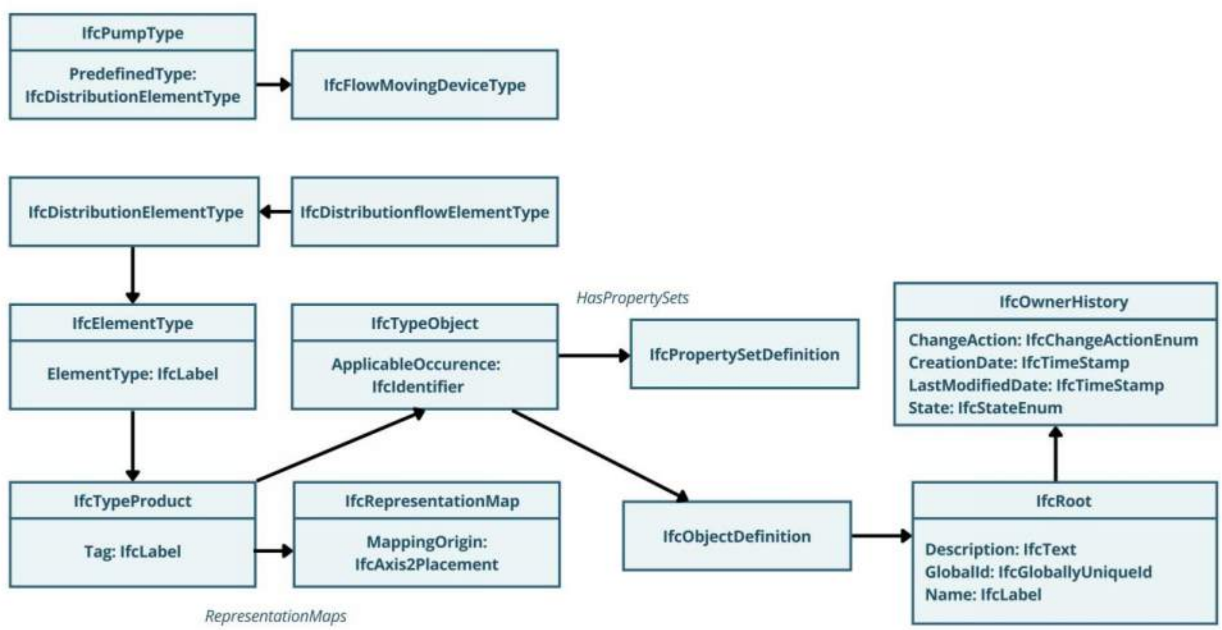

Figure 16 Data Schema from IFC 4.3 for a Pump

Recommendations for NRC CDF

Conceptual and operational models, representation languages, and schemas are primarily developed and maintained by dedicated third-party organizations. It is unlikely that NRC will need to develop its own resources to ensure conceptual interoperability. Instead, NRC is encouraged to use and build upon these existing resources. Specifically, any orientations taken, or resources developed by NRC in the context of the PDCSS should leverage existing models, languages, and schemas that are open and freely accessible. Notably, IFC is one of the only certified standards that offers a comprehensive solution for mapping information related to the built environment and their relationships. By adopting these approaches, Government bodies, Non-Governmental Organizations, and third-party vendors can build upon NRC's work, providing open and transparent services to stakeholders in the Canadian built asset industry. Appendix 4 provides a subset of available conceptual resources for the built asset industry, focusing on specifications, materials, and codes.

4.2.4. Processes and Workflows

Alongside data, processes and workflows are foundational pillars of digitalization in the built asset industry. Processes are defined as “sets of interrelated or interacting activities that transform inputs into outputs” (ISO 9000:2005, 3.4.1), while workflows are “series of activities necessary to complete a task” (ISO 20186-2:2019, 3.28). Through its digitalization program, NRC is facilitating the transition to digital workflows, thereby supporting the reconfiguration and reengineering of business processes within the built asset industry. This reconfiguration, and more importantly ensuring process interoperability, is crucial for digitalization to deliver tangible benefits, particularly through automation.

Process interoperability aims to ensure that organizational systems can work together seamlessly to achieve common goals by harmonizing business processes through coordinated tasks, data flows, and orchestrated interactions. Consequently, the way in which NRC and other Canadian built asset industry stakeholders conduct business is being and will increasingly be transformed—from the identification of organizational objectives to the assurance and control of information deliverables. These processes and workflows are structured through information or model uses, guided by information delivery manuals (IDM; ISO 29481, shown in Figure 17), and leverage concepts such as Level of Information Need (ISO 7817-1:2024) or specifications for information delivery (e.g., IDS).

As discussed in Poirier et al. (2022), **Information Uses**—sometimes referred to as BIM uses, model uses or use cases—"frame and define specific processes, inputs, technologies, and deliverables to enable decision-making and support specific outcomes" (p. 18). More specifically, the authors, citing Kreider and Messner (2013), indicate that “a BIM Use can be defined as a method of applying Building Information Modelling during a facility’s lifecycle to achieve one or more specific objectives.” Model uses, on the other hand, are defined as “The intended or expected Project Deliverables from generating, collaborating on and linking Models to external databases. A Model Use represents the interactions between a User and a modelling system to generate Model-based deliverables. There are dozens of Models Uses including Clash Detection, Cost Estimation, and Space Management” (BIM Dictionary, 2022). Poirier et al. (2022) conclude by indicating that "over the years, several strategies have been developed to classify, structure, and document BIM uses, such as the work by Penn State, through the BIM Dictionary, and by buildingSMART International" (p. 18). In the context of the NRC’s DCP, an information use library or catalogue would be highly beneficial to all stakeholders involved, allowing them to easily browse and access specific information uses and their descriptions (see Services).

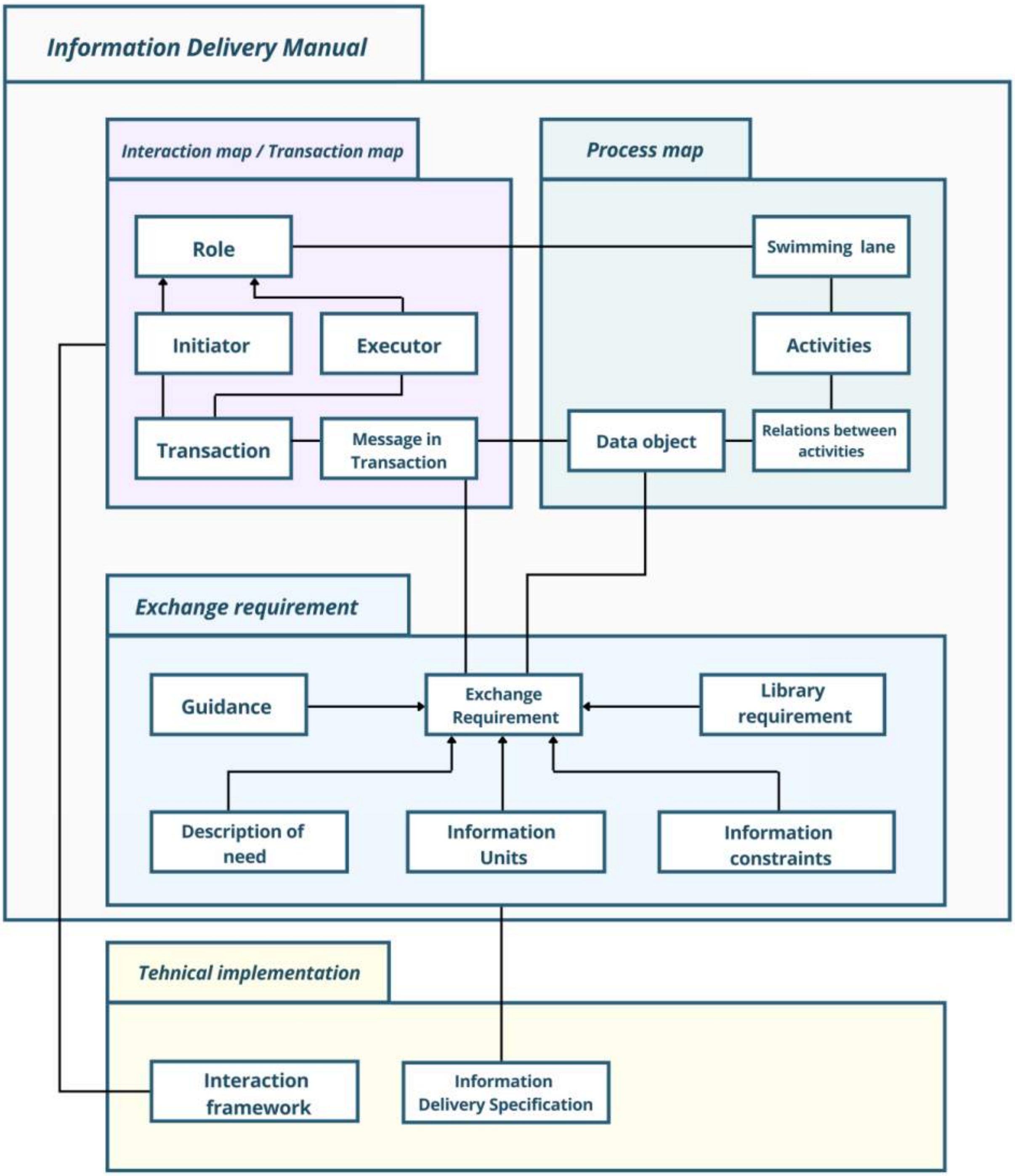

Figure 17 IDM basic framework (from ISO 29481-1, 2016)

In this regard, information uses can be standardized according to ISO 29481 through an **Information Delivery Manual (IDM)**. An IDM is defined as "documentation which captures the business process and gives detailed specifications of the information that a user fulfilling a particular role would need to provide at a particular point within a project" (ISO 29481-1, 2016). Figure 17 illustrates the basic framework of an IDM, highlighting three core aspects: interactions/transactions, processes, and exchange requirements.

One critical aspect of implementing an information use is that it must serve a specific purpose, driven by a business need, while delivering only the necessary information. The concept of **Level of Information Need (LOIN)**, defined as a "framework which defines the extent and granularity of information" (ISO 19650-1:2018, 3.3.16), provides clarity around the various Levels of X (LoX) that have emerged to guide the development and progression of information model content. Over the past decade, LoX has been described in various forms, including Level of Accuracy (LoA), Level of Completeness (LoC), Level of Coordination (LoC), Level of Detail (LoD), Level of Development (LoD), and Level of Information (LoI), as highlighted by (Bolpagni, 2016). Numerous resources have been developed to define and specify LoX, with the LoD resources by the BIM Forum in the US and the GID resources from the DigitalBuilding group in Luxembourg being notable examples. The Level of Information Need framework is structured around four prerequisites—purpose, milestones, actors, and objects—and three components: geometry, data, and documents, as shown in Figure 18

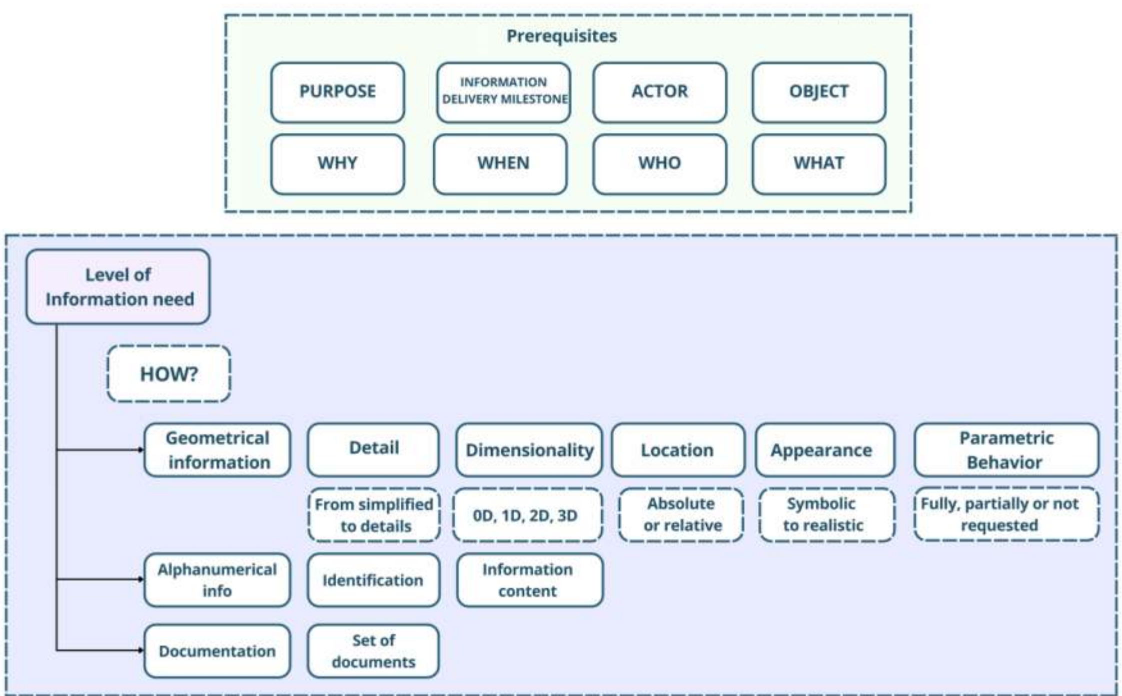

Figure 18 Level of information need framework (Adapted from ISO 7817-1, 2024)

As the purpose, use, and definition of specific information are formalized through the standards discussed above, various workflows and their underlying techniques can be employed to require, deliver, and validate this information. Numerous solutions exist to specify, translate, and fulfill information requirements, as shown in Figure 19. One notable solution is buildingSMART International's Information Delivery Specification (IDS), which has been developed to define "information requirements in a way that is easily read by humans and interpreted by computers" (bsi, 2024).

○ – No
◑ – Partial
● – Yes
* – under development

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			Fields					Value constraints				Content			Geom.		Metadata		
	Standardised	Applicability	Info. type	Data type	Unit of meas.	Description	References	Equality	Range	Enumeration	Patterns	Existence	Documents	Structure	Representation	Detailedness	Purpose	Actors	Process map
Spreadsheet	○	◑	◑	◑	◑	◑	◑	◑	○	○	○	○	○	○	○	○	◑	○	○
PDT*	●	◑	◑	●	●	◑	●	○	◑	●	○	◑	○	○	○	○	◑	○	○
Data Dict.	●	○	●	●	◑	●	●	●	◑	●	◑	○	○	○	○	○	○	○	○
IDS*	●	●	●	●	●	◑	◑	●	●	●	●	●	○	◑	○	○	●	◑	○
mvdXML	●	●	●	●	●	◑	○	●	●	◑	◑	◑	○	●	●	○	○	◑	○
idmXML	●	◑	◑	◑	◑	●							●		◑	◑	●	●	●
LOIN*	●	◑	◑	●	●	◑	◑	○	○	●	○	○	●	◑	◑	●	●	●	○
IFC P.T.	●	◑	◑	●	●	◑	○	○	○	●	○	○	○	○	○	○	○	○	○
LD+SHACL	○	●	●	●	●	◑	●	●	●	●	●	◑	◑	●	●	○	◑	◑	○

Figure 19 Comparison of information delivery standards and specification mechanisms (Taken from Tomczak et al., 2022)

An IDS enables built asset industry stakeholders to define exchange requirements in a structured and repeatable manner, using formats that are interpretable by both humans and computers. It allows users to specify properties such as materials, classifications, dependencies, and relationships for various entities.

Figure 20 presents the IDS Implementation Workflow, offering a structured process for built asset industry stakeholders to define exchange requirements. While the workflow itself is comprehensive, it is crucial to recognize additional approaches that can be derived from this diagram, which further enhance its utility. One such approach is the establishment of a data interoperability framework that supports consistent and seamless data exchanges across various stages of the asset lifecycle. This framework ensures that information is uniformly structured, thereby minimizing the risks associated with miscommunication and data loss.

Additionally, Figure 20 suggests the potential for integrating automated compliance checking within the IDS framework. By embedding relevant rules and industry standards directly into the exchange process, stakeholders can ensure that all data exchanges adhere to regulatory requirements and project-specific criteria without requiring extensive manual oversight. The diagram also implies the possibility of customizing the IDS for specific project needs, enabling stakeholders to tailor the exchange process to accommodate unique project characteristics, such as specialized materials or bespoke classification systems, thereby enhancing the IDS' flexibility and applicability.

Furthermore, the diagram highlights the opportunity for integrating the IDS with existing BIM tools. Such integration facilitates more seamless information exchanges, allowing for real-time updates and reducing the need for data conversion or re-entry. These approaches, when considered alongside the core IDS Implementation Workflow, create a robust framework that significantly improves the effectiveness and efficiency of data exchange within the built asset industry.

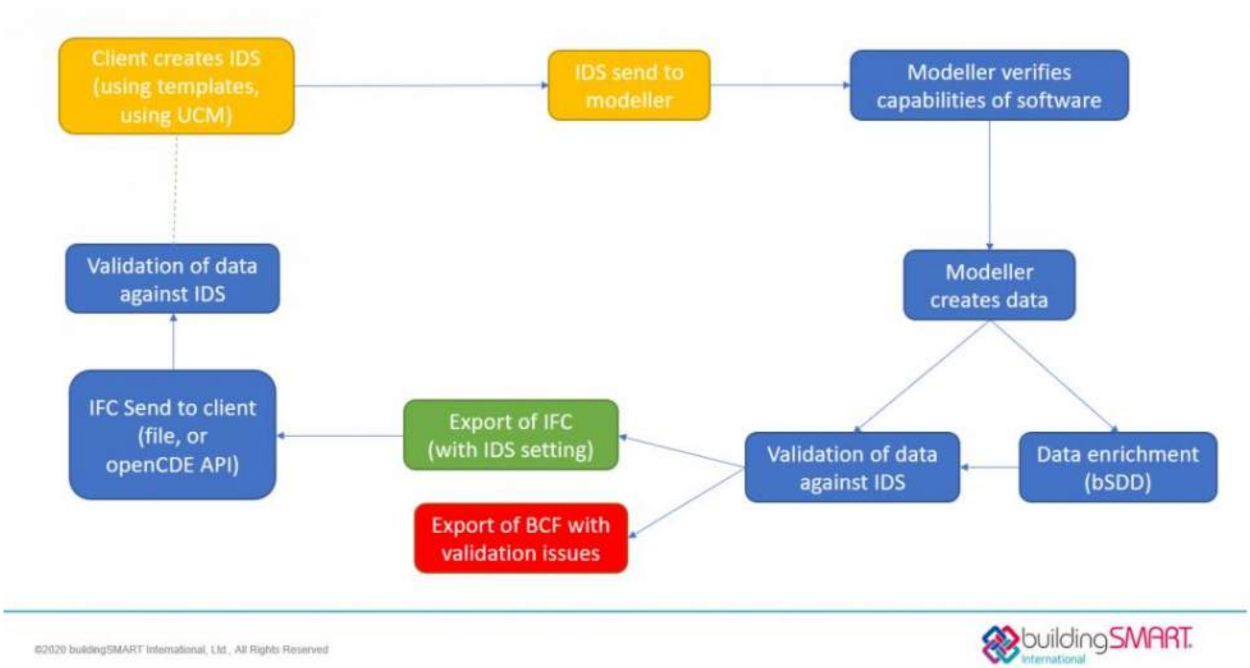


Figure 20 IDS Implementation workflow (Taken from buildingSMART International, 2020)

Recommendations for NRC CDF

To enable process and workflow interoperability, NRC should adopt and promote existing mechanisms and standards such as information or model uses, Information Delivery Manuals (IDM; ISO 29481), the concept of Level of Information Need (ISO 7817-1:2024), and specifications for information delivery (e.g., IDS). These resources, primarily developed and maintained by organizations like ISO and buildingSMART International, provide a robust framework for ensuring consistency and interoperability.

For instance, in the digitization of codes and the transition toward e-permitting, NRC should consider creating and making their codes available as a catalogue of IDS', where code requirements are computable. Machine-readable rule formalization would significantly advance the digitalization of the NMCC, creating a direct link between professional designs and the codes. This integration would help maintain compliance throughout the design and construction process, reducing the risk of errors and inconsistencies. Appendix 3 provides a subset of available process and workflow-related resources for the built asset industry.

4.2.5. Practices and Methodologies

Practices defined as "specific type of activity that contributes to the execution of a process" (PMBOK Guide, 4th Edition) encompass the day-to-day operations and tasks performed by various stakeholders involved throughout the lifecycle of Canadian built assets. Whether internal to NRC or external industry stakeholders, these activities are facilitated by processes, tools, and technologies that apply methodologies and complimentary services. They are crucial for planning, delivering, and utilizing the Canadian built environment. Within the framework of NRC's Digital Construction Platform (DCP), standardization or harmonization of numerous practices and methodologies is essential for successful digital transformation. This includes practices in management, security, modelling, and other pertinent areas.

Numerous **Management Standards** support various aspects within organizations (ISO 9001), projects (ISO 21000), assets (ISO 55000), facilities (ISO 41000), and information (ISO 19650). These standards offer specifications, codes of practice, and methods that guide practitioners in accomplishing tasks and achieving outcomes related to their respective domains.

Data and Information Security is a key concern across built asset supply chains and lifecycles, especially for public asset owners. Mechanisms supporting data and information security include **Data Governance**, including data stewardship, data quality management, and data lifecycle management, to maintain the reliability and accuracy of shared data, **Data Protection and Privacy**, namely compliance with ISO/IEC 27018:2019 (Protection of personal data in the cloud), GDPR (General Data Protection Regulation) and **Data Integrity and Security** which are supported by established practice and technical standards, such as ISO 19650 Part 5 and ISO 27000, which are continually evolving. Concurrently, various government entities have developed policies and guidelines to address data and information security concerns. For instance, the National Institute of Science and Technology (NIST) in the US also provide guidelines to ensure the protection and integrity of data during exchange and storage. In Canada, the Government of Canada's Contract Security Manual (CSM) outlines requirements for private sector organizations to safeguard government information and assets when awarded contracts with specific security stipulations (Government of Canada, 2017).

Modelling Standards and Guidelines establish the rules for creating and interpreting models, ensuring consistency in their representation across diverse systems and applications. These modelling standards and guidelines exist in many forms and have been developed by different organizations and client bodies. The standards and guidelines will have to be developed to support instantiation of the practices and services made available by NRC. These standards, along with the various resources mentioned above (classifications, nomenclatures, terminologies, representations, etc.), serve to frame the model development process.

Recommendations for NRC CDF

Existing management, security, and modelling standards and guidelines should be mandated for use by NRC or at least referenced. These resources are predominantly developed and maintained by dedicated third-party organizations, notably ISO and other Standards Development Organizations (SDOs). Depending on availability and relevance, NRC may consider requesting or supporting the development of specific resources.

4.2.6. Services

Services play a crucial role in supporting practices and methodologies by offering essential functions, interfaces, and capabilities within appropriate environments (ISO 19119:2005). These environments include specific platforms and the connections between them, facilitated notably through Application Programming Interfaces (APIs). APIs are a set of rules and tools that allow different software applications to communicate with each other. APIs define the methods and data formats that applications can use to request and exchange information. They serve as an intermediary that enables integration between different systems, allowing them to work together seamlessly. Within these environments and platforms are subsets like engines and interfaces, which deliver specific functionalities to end users, enabling them to achieve targeted outcomes.

Microservices are defined through ISO/IEC 25010:2011 (System and software quality models) which provides guidelines for designing microservices architectures, which support flexibility and scalability. Technologies like containerization (e.g., Docker) and orchestration (e.g., Kubernetes) are essential for deploying microservices.

In terms of digital repositories, **Cloud Computing** has rapidly become an industry go to, with standards such as ISO/IEC 17788:2014 (Cloud computing overview and vocabulary) defining cloud service models (IaaS, PaaS, SaaS). Cloud providers like AWS, Azure, and Google Cloud offer scalable and flexible infrastructure for hosting the NRC DCP.

Interfaces and Webservices facilitating digitalization within the built asset industry include buildingSMART International's Use Case Management (UCM) tool (ucm.buildingsmart.org) and

BIMexcellence's BIM Dictionary (bimdictionary.com). The UCM "[...] enables the capture, specification, and exchange of best practices [pertaining to information uses], making them accessible industry-wide" (bSI, 2024). Similarly, the BIM Dictionary is a collaborative effort to establish a reliable resource and common understanding of frequently used terms across the Built Environment" (BIMdictionary.com, 2019).

Another significant service is the bSDD, a comprehensive public repository for data dictionaries across entities in the built environment. It focuses on standardizing terminology rather than storing specific data, effectively serving as metadata. The bSDD addresses challenges related to common terminology and allows organizations to enhance the IFC schema by adding specific properties not covered in the current schema. This flexibility enables organizations to customize their data requirements according to their unique needs. Additionally, the bSDD offers a detailed framework for metadata, encompassing definitions, codes, dictionary affiliations, versions, ownership, parent classes, associated property sets, and unique identifiers (UIDs).

Alternative services include specialized applications for various aspects of the built asset lifecycle, including design, construction, and maintenance and mobile applications for on-site data collection and real-time collaboration. These are characterized by the use of augmented reality (AR) and virtual reality (VR) applications for immersive design reviews and on-site construction assistance.

Application Programming Interfaces (API) are a "collection of invocation methods and associated parameters used by one piece of software to request actions from another piece of software" (ISO/IEC 18012-1, 2004). BuildingSMART International spearheads the openCDE initiative, described as '[...] *a suite of API standards [...]' consisting of a foundational API upon which various APIs are built, such as the BIM Collaboration Format (BCF) API, Documents API, and bsDD API* (bSI, 2019/2024). From a broader perspective, protocols for API connections, such as RESTful APIs, SOAP, and openCDE APIs, to ensure they support seamless data exchange between different CDEs while investigating the use of GraphQL and other modern API standards support flexible and efficient data queries and exchanges.

In parallel, the GIS domain has established services, functionalities, and resources, defined through the ISO 191115 suite of standards. These standards ensure a comprehensive and systematic approach to geospatial data management and integration.

Recommendations for NRC CDF

Within the Common Data Framework, NRC can tap into existing tools like the UCM tool, the BIM Dictionary, and the bSDD. Moreover, NRC has the opportunity to harness a wide array of GIS resources and API catalogues to bolster the development of the DCP. By leveraging these resources, NRC could identify and define the essential parameters and metadata crucial for the NMCC, NMS, and CCMC evaluations and other resources.

Although the bSDD does not currently offer services specifically designed for NMS and CCMC, it can be adapted and repurposed to host and manage these resources effectively. This adaptability makes bSDD a versatile platform for integrating and managing the necessary metadata and standards within the overarching Common Data Framework.

By aligning these resources with the bSDD, professionals can establish a framework that allows for the integration and connection of information in their models with the standards published by NRC. This framework would enhance consistency and accuracy in the application of building standards and regulations, facilitating better compliance and quality control.

Adopting the bSDD can promote interoperability across different software platforms and among stakeholders within the construction industry. By using a common terminology and metadata framework, NRC can ensure that all parties involved in a project have a clear and consistent understanding of the standards and requirements, thereby reducing miscommunication and errors. Additionally, for the DCP, NRC could leverage the openCDE initiative, which provides a suite of API standards to facilitate seamless data exchange and collaboration.

In terms of storage and repositories, NRC will have to investigate the appropriate services in tandem with governmental policies and requirements.

By integrating comprehensive resources for syntax, semantics, concepts, processes, practices, methodologies, and supporting services, NRC can set the common data framework for the Canadian built asset industry. Adopting and implementing the CDF, through application within its services, will ensure interoperability and efficiency for Tier 2 of the meta-framework: Common Data Environments and Digital Platforms.

4.3. Tier 2 - Common Data Environments and Digital Platforms

The NRC Digital Construction Platform (NRC DCP) is proposed as a comprehensive "system-of-systems" designed to enhance collaboration, data exchange, efficient management and use of NRC's resources within the Canadian built asset industry (Figure 21). The platform is defined through a layered architecture which articulates a series of interconnected environments, components and stakeholders (more detailed version is shown in *Figure* 22whereby the development process and states are identified, and information flows illustrated). In addition, connections to external platforms are shown. In this sense, the NRC DCP centralizes information from different NRC departments and other government agencies. While primarily used for outward information sharing, it allows for submissions and feedback to NRC. Centralizing regulatory documents and resources facilitates linking and cross-referencing.

The core layer is comprised of the foundational components from Tier 1 (CDF), which are leveraged as resources within the NRC DCP to maximize functionalities offered through the platform. This ensures a scalable and modular approach to the development of the platform and enables integration of emerging resources as they become available.

The second layer is the virtual ecosystem itself (the platform), composed of repositories to support development and publication of the NRC's resources as well as the web services and user interfaces allowing access and utilization of these resources. The platform follows the principles of a CDE as described in ISO 19650 as it pertains to the process and its underlying mechanisms (metadata, classifications, nomenclatures, etc.). Given the NRC'S organizational structure, each NRC sector (NMCC, CCMC, and NMS) will possess its own virtual space to support internal collaboration and information exchange and connect to others via APIs for seamless exchange and enhanced cross-sector communication.

The third layer is the user layer and is related to the third tier of the NRC DCP, namely the services deployed to fulfill specific purposes as discussed below.

Overall, the NRC DCP is an integrated, centralized repository of information encompassing various departments within the NRC as well as other government agencies. This platform serves as a vital tool for the dissemination of regulatory documents, standards, and resources, facilitating improved access and ensuring usability for industry professionals, governmental bodies, and other key stakeholders.

The primary function of the NRC Digital Construction Platform is to provide an outward-facing portal for sharing comprehensive and up-to-date information. Additionally, the platform incorporates a feedback mechanism, allowing external users to submit information and provide feedback, fostering a dynamic and interactive environment. By centralizing numerous regulatory documents and resources, the platform significantly enhances the ability to link and cross-reference information, thereby improving the coherence and consistency of the data available.

Key departments within the NRC rely on the platform for collaboration and information exchange. Each department operates within its own CDE, which are interconnected through APIs. This interconnectivity ensures a seamless exchange of information and promotes cross-sector communication, thereby bridging silos and fostering a more integrated approach to regulatory compliance and construction innovation.

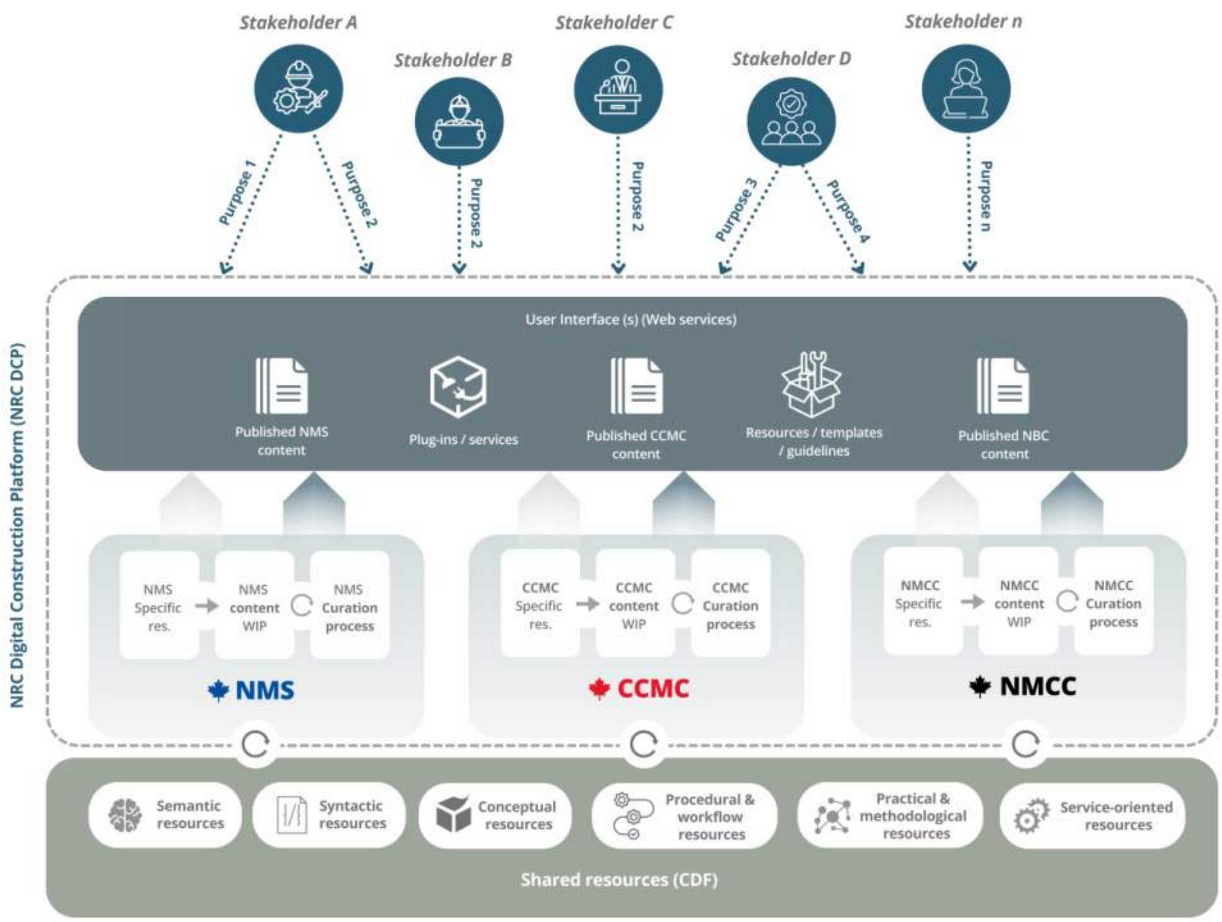


Figure 21 NRC DCP Conceptual architecture

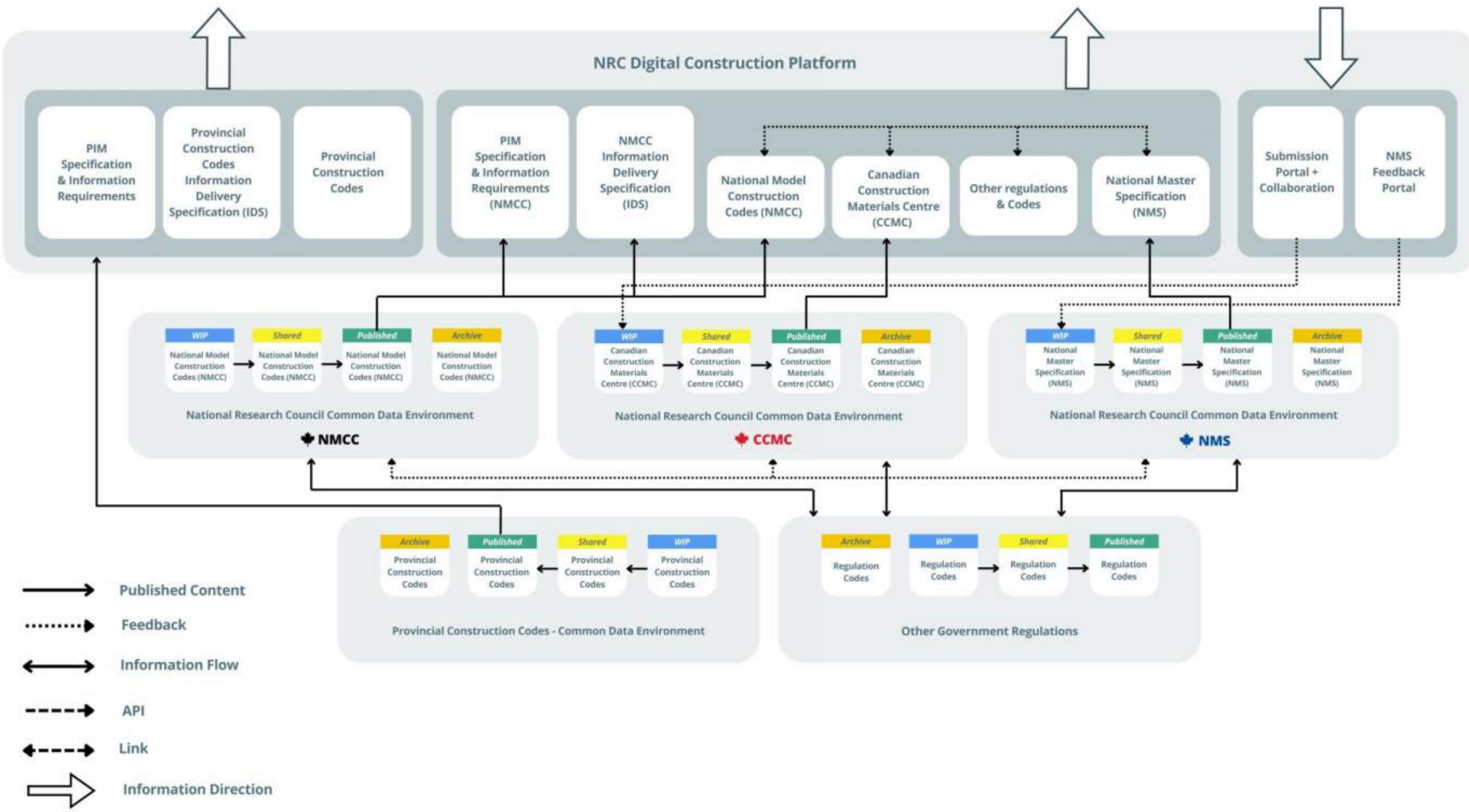


Figure 22 NRC DCP detailed architecture and information flow

4.3.1. Stakeholders

Within the NRC DCP, stakeholders represent diverse entities involved in the Canadian built asset industry, such as regulatory bodies, industry professionals, and other relevant organizations. These stakeholders engage with the platform for various defined purposes, ensuring their specific needs and goals are met through the NRC DCP's offerings. It can include accessing standards, submitting feedback, and utilizing digital tools. Fundamentally, the NRC DCP deals with three core stakeholder groups as they relate to their service offerings, be it the NMS, the NMCC and the CCMC. Each stakeholder group is summarized below.

4.3.1.1. NMS Stakeholder Group

As previously stated, the NMS is managed and maintained by the NRC with continuous review and updates by industry specialists. The structured update process and the involvement of various committees and task groups ensure that the NMS remains relevant and up to date, reflecting regional differences and advancements in technology and industry practices. Table 5 identifies the main stakeholders using or involved with the NMS:

Table 5 Principal stakeholders using or involved with the NMS (Adapted from Canada, 2019b)

Stakeholder Category	Generic Role	Example Use Case
Specification Writers	Create accurate construction documents	As a specification writer, utilize the NMS to develop customized, up-to-date specifications for projects.
Architects & Engineers	Ensure design and engineering standards are met	As an architect, utilize the NMS to ensure designs comply with industry standards and regulatory requirements. Provide user-friendly tools for creating and managing specifications and offer detailed specification templates and guidelines.
Interior Designers	Adapt specifications to include design elements	As an interior designer, incorporate aesthetic elements into NMS specifications.
Construction Specialists	Tailor specifications to specific project needs	As a construction specialist, customize NMS to fit unique project requirements.
Government & Private Sector	Customize NMS for various projects	As a government official, use NMS to standardize specifications for public sector projects.
National Research Council (NRC)	Develop and maintain NMS	As part of NRC, ensure NMS is comprehensive and up to date.
Authorized Publishers	Distribute and enhance NMS usability	As a publisher, distribute NMS and create tools to improve its accessibility.

Stakeholder Category	Generic Role	Example Use Case
Government Agencies	Enforce standards and broaden NMS usage	As a government agency, mandate the use of NMS to ensure compliance and competitive bidding.
Construction Contractors & Companies	Implement NMS in construction projects	As a contractor, utilize the NMS to guide construction and ensure adherence to standards.

4.3.1.2. CCMC Stakeholder Group

As described on its website, the CCMC "[...] operates several committees related to product assessment, which provide a variety of functions [...]", as shown in Table 6:

Table 6 CCMC's committees related to product assessment (Taken from CCMC website (Canada, 2019a))

Committee Name	Function	Member Selection Criteria	Member Composition
CCMC Stakeholder Committee- Canadian Commission on Construction Material Evaluations (CCCME)	Represents private industry, public sector, construction regulators, assessment users, and clients	Members are determined through a selection process as defined in its policies and procedures	Representatives from private industry, public sector, construction regulators, CCMC assessment users (AHJs and design professionals), and CCMC clients (manufacturers and distributors)- Open to members and approved guests only
CCMC Scheme Committee	Technical approval authority for CCMC certification schemes	Chosen by the CCMC based on their technical competence and experience in particular domains	Members from academic and/or consultant organizations to minimize potential conflicts of interest
CCMC Appeals Committee	Provides external perspective on appeals and makes final appeal decisions	Knowledge and experience in a regulatory or conformity assessment framework demonstrated professional conduct in their field	Members selected by the CCMC based on their knowledge and experience in regulatory or conformity assessment frameworks and their demonstrated professional conduct
CCMC Impartiality Committee	Provides third-party review of CCMC operations to ensure	Chosen by the CCMC from the industry at large, composed of professionals experienced in conformity assessment who	Professionals experienced in conformity assessment and knowledgeable in product certification

Committee Name	Function	Member Selection Criteria	Member Composition
	impartiality in certifications	are knowledgeable in product certification	

Table 7 identifies the main stakeholders using or involved with the CCMC:

Table 7 The main stakeholders using or involved with the CCMC (Adapted from CCMC website (Canada, 2019a))

Stakeholder Category	Generic Role	Example Use Case
Regulatory Bodies	Ensure product compliance with building codes	As a regulatory body, recognize CCMC evaluations to ensure building code compliance.
Federal Agencies	Approve products for public sector projects	As a federal agency, use CCMC evaluations to approve products for public construction projects.
Industry Associations	Support and promote CCMC evaluations	As an industry association, support the use of CCMC evaluations to ensure product standards
Testing and Inspection Entities	Provide data for product certification	As a testing entity, generate reports used by CCMC for product certification decisions.
Expert and Personnel Entities	Provide technical analyses and verify competence	As a subject matter expert, provides technical analyses to support CCMC's certification processes.
Management and Oversight Bodies	Assess and ensure compliance with standards	As a management body, assess systems and provide audits to ensure compliance with CCMC standards.
Data Providers	Supply reliable data for certification	As a data provider, supply essential data for CCMC certification.
Construction Industry	Use CCMC evaluations to approve innovative products	As a construction professional, use CCMC evaluations to approve innovative products for projects.
Architects	Use of validated construction materials for building design and compliance with standards.	As architects, provide access to a comprehensive database of materials
Engineers	Access to detailed product specifications and performance data for engineering assessments	As Engineers, offer detailed technical documentation and data
Municipal Bodies	Ensure compliance with municipal building codes and facilitate approval processes	As Municipal Bodies, facilitate integration with municipal e-permitting systems

4.3.1.3. NMCC Stakeholder Group

Table 8 identifies the main stakeholders using or involved with the NMCC:

Table 8 main stakeholders using or involved with the NMCC

Stakeholder Category	Generic Role	Example Use Case
Architects & Engineers	Design and ensure compliance with construction standards	As an architect, use NMCC to access codes and ensure designs comply with regulations.
Builders	Execute construction projects according to standards	As a builder, use NMCC to access codes during the construction phase to ensure compliance.
Building Owners	Submit applications and receive permits	As a building owner, use NMCC to submit building permit applications and receive results through the portal.
Operators	Obtain operating licenses and ensure regulatory compliance	As an operator, use NMCC to receive operating licenses through the portal.
Environmental Groups	Ensure environmental concerns are included in regulations	As an environmental group, access NMCC to ensure environmental concerns are considered in building codes.
Manufacturers & Business Interests	Provide products and services meeting code standards	As a manufacturer, ensure products meet the standards set out in the NMCC.
Government Regulatory Bodies	Adopt, modify, and enforce building codes	As a regulatory body, adopt and modify NMCC to suit local conditions and ensure compliance.
Third-Party Developers	Develop tools and systems for code checking	As a third-party developer use NMCC to develop checkers and systems based on published specifications.

4.3.2. Digital Ecosystems and Their Underlying Processes

The NRC DCP is an ecosystem comprised of repositories and services that provides each NRC organizational units (NMCC, CCMC, and NMS) its own virtual space to support internal collaboration and information exchange and connect to others via APIs for seamless exchange and enhanced cross-sector communication. As such, the proposed **Content Development and Curation Processes** should include and/or support the following:

- **NMS Specific Resources**: Tools and materials specific to the NMS content development.
- **NMS Content WIP (Work-In-Progress):** Content under development or review for NMS.

- **NMS Curation Process (Internal)**: Internal workflows for curating and finalizing NMS content before publication.
- **CCMC Specific Resources**: Specialized resources focused on code compliance assessments.
- **CCMC Content WIP**: Draft content under review and development for CCMC.
- **CCMC Curation Process (Internal)**: Processes involved in refining and finalizing CCMC content.
- **NMCC Specific Resources**: Tools and resources pertinent to the National Building Code.
- **NMCC Content WIP**: Content in the development or revision stage for NMCC.
- **NMCC Curation Process (Internal)**: Procedures for curating and preparing NMCC content for publication.

In addition, the **NRC DCP User Interface (Web Services)** acts as the central access point for all stakeholders, allowing seamless interaction with published content, services, and resources. Content and resources are developed, curated, and then made available through the user interface, ensuring high standards of quality and accuracy. The following items could be made available through the interface:

- **Published Content**: NMS, CCMC, and NBC Content.
- **Plug-ins/Services:** Additional functionalities and integrations that enhance the user experience and streamline processes.
- **Resources/Templates/Guidelines:** Supplementary materials to support users in adhering to standards and best practices.

4.3.2.1. Digital Ecosystem Requirements

Table 9 details the requirements of the digital ecosystem that are key to the successful deployment of the NRC's DCP. These requirements were identified through a comprehensive process that included engaging with stakeholders, examining best practices from global initiatives, and assessing the current state of digitalization in the Canadian construction industry. Each requirement is crucial for different reasons, such as ensuring systems can work together smoothly, improving how data is integrated, and supporting the DCP’s overall goals, including boosting efficiency, enabling automated compliance checks, and encouraging sustainable building practices. For instance, the emphasis on data interoperability is vital because it allows different digital platforms and tools to communicate effectively, which is critical for creating a comprehensive digital ecosystem. Additionally, requirements related to security and privacy are essential to safeguard sensitive information and ensure adherence to regulatory requirements.

Table 9 Digital ecosystem requirements

Requirement	Description
Centralized Data Management	Centralize regulatory documents and resources to facilitate linking, cross-referencing, and outward information sharing.
Modular Architecture	Implement a scalable and modular approach for the platform to enable integration of emerging resources.
Interconnected Environments	Create a series of interconnected environments, components, and stakeholders to enhance collaboration and data exchange.
APIs for Seamless Exchange	Utilize APIs to ensure seamless exchange and enhanced cross-sector communication between different virtual spaces of NRC departments.
User Interface (Web Services)	Develop a central access point for stakeholders to interact with published content, services, and resources.
Content Development and Curation	Support internal collaboration and information exchange for content development, WIP, and curation processes specific to NMCC, CCMC, and NMS.
Published Content Management	Maintain high standards of quality and accuracy for published content available through the user interface.
Plug-ins and Additional Services	Provide additional functionalities and integrations to enhance user experience and streamline processes.
Resource Templates and Guidelines	Offer supplementary materials to support users in adhering to standards and best practices.
Quality Assurance	Implement quality control measures to ensure the reliability and accuracy of digital content and processes.
Training and Support	Develop training programs and support materials to upskill stakeholders and ensure effective platform use.
Communication Strategy	Establish a communication strategy to effectively engage and inform all stakeholders involved in the platform.
Project Management	Structure and manage project activities to ensure timely and efficient platform delivery and maintenance.
Governance Mechanisms	Implement governance structures to oversee platform operations and ensure compliance with standards and policies.

4.4. Tier 3 - Digital Services and Functions

The NRC's DCP is designed to address the diverse needs of stakeholders in the Canadian built asset industry through a comprehensive suite of services and functions. Tier 3 specifically focuses on the processing and utilization of data related to digital codes and e-permitting processes, material passports, and includes use cases such as Life Cycle Assessment (LCA) and other analytical processes. Tier 3 builds upon the common data frameworks established in Tier 1 and employs the digital ecosystem described in Tier 2. By utilizing these foundational elements, Tier 3 aims to enable the development and deployment of the services required to facilitate use of NRC's resources to achieve the objectives of the PDCSS.

Given the modular and scalable nature of the NRC DCP, tier 3 services and functions are articulated as modules to be built and/or offered by NRC, other government bodies, or third-party stakeholders. Naturally, the services offered would align with one of NRC's three key resource areas (NMCC, NMS, CCMC). These three areas and the scenarios relating to the digitalization of each are discussed below. It is important to note that while each of these scenarios is presented independently, the proposed architecture views them as integrated to the extent possible and using the same resources as defined through tiers 1 and 2. As such, the platform will follow these three core principles:

- **Centralized Data Management:** The NRC platform's central data repository integrates various services, ensuring that data from Digital Specifications, Land-Use Plans, and Building Permit Services are consistently managed and accessible.
- **OpenBIM principles and APIs for Interoperability:** Where applicable, openBIM principles will be followed to ensure data interoperability, whereas APIs, such as RESTful APIs guided by open API principles, will facilitate data exchange between services and external systems, ensuring seamless integration and interoperability.
- **Intra-agency communication**: The platform's communication services enable effective collaboration between different services and stakeholders.

As mentioned, each of NRC's three key resource areas will be supported through the DCP within its own ecosystem, which is then integrated within the overarching platform. To present how the services will be delivered through tier 3, user scenarios for each of the three key resource areas have been developed and are discussed below. These user scenarios are forward-looking narratives that demonstrate how various stakeholders—including industry professionals, manufacturers, government agencies, and third-party software providers—involved in the development, publication, and utilization of NMCC, NMS, and CCMC content, as well as the building permit and compliance check processes, might leverage the NRC DCP in their work. These scenarios highlight advanced data management systems, BIM compatibility, CDE interoperability, API integration, automated compliance checking, enhanced collaboration tools, and improvements in regulatory and permit processes. The user scenarios operationalize the target state presented in target states for the NRC DCP and serve to identify the requirements for the NRC DCP roadmap.

4.4.1. NMCC User Scenarios

The NMCC (Figure 23) will leverage the NRC Digital Construction Platform to share its content publicly to Industry Professionals as well as provincial, municipal and other Government Agency regulators, each of which will have their own common data environments and exchange information as required. Third-party software providers will also connect via APIs to provide service applications. The NMCC will be shared with collaborating government agencies from the NRC NMCC CDE to support the creation of provincial or regional versions of the national building code which will be shared on the NRC Digital Construction Platform when approved and published. Provincial, municipal and other Gov. Agencies CDE's will connect to the NRC Digital Construction Platform to exchange information via openCDE API connections. The more detailed components of NMCC in connection to NRC DCP is shown in Figure 23.

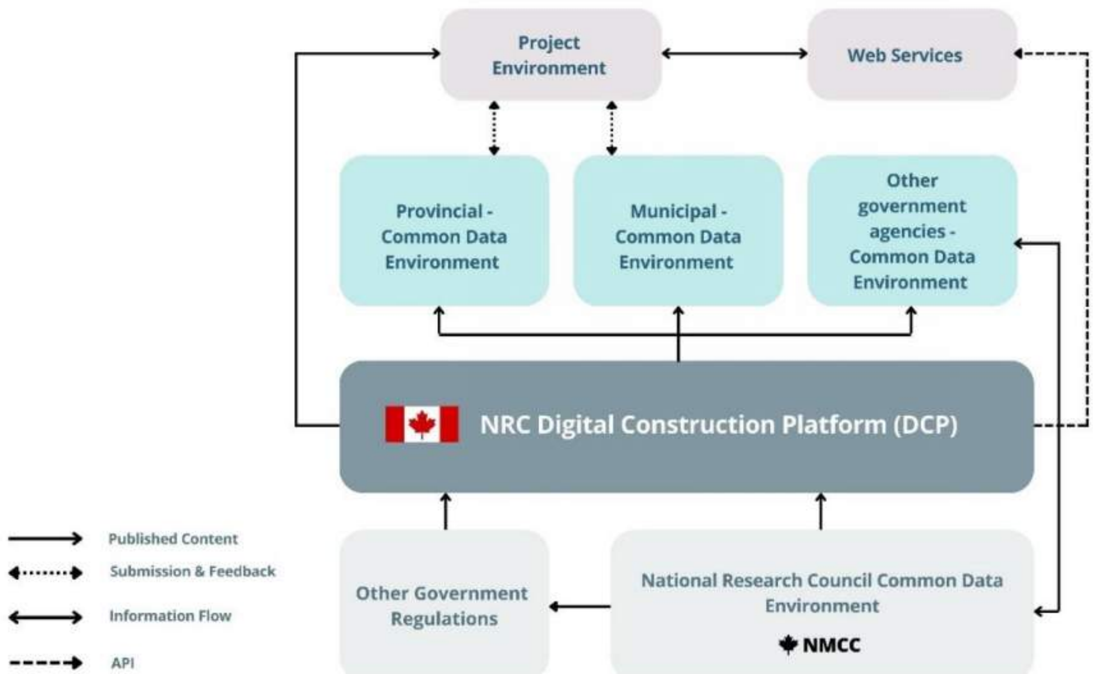


Figure 23 Overview of the NMCC connection to the NRC Digital Construction Platform

Industry professionals can access the NMCC content via the applicable regulatory body, the web services, or directly from the NRC Digital Construction Platform. NMCC content will include PIM Specifications and Information Requirements, the IDS file to allow for the automated code checks and the NMCC. The same content will be adjusted to reflect each provincial or regional code.

Web Services

Third-party vendors can access the latest published NMCC content from the NRC DCP for use in their applications and services. These web services are accessible independently. Additional services, many of which have been identified through the ACCORD project could include:

- **Digital Code Management services**: Consists in digitizing building codes using machine-readable formats and structured data representations. Could be supported by exploring best practices and international examples, such as the International Code Council (ICC) digital codes.
- **Rule Configuration Service**: The Rule Configuration Service relies on the Digital Specifications to configure rulesets based on up-to-date specifications and regulations. It defines the rules used by various compliance checking services.
- **Building Permit Decision Support**: "This service provides access to diverse building permit services, databases, and archives." It utilizes data and rules configured by the Rule Configuration Service to support decision-making for building permits.
- **Land-Use Plans Conversion Service**: Converts land-use plans into standardized formats that comply with OGC geospatial encoding rules. This standardized data is used by the "Land Use Compliance Checking Service for verification."
- Compliance Checking Services:
    - **Land Use Compliance**: Utilizes standardized data from the Land-Use Plans Conversion Service and checks compliance of CityGML and IFC models against land use requirements.
    - **Building Permit Compliance**: This service uses a BIM viewer to check compliance against rules and generates compliance reports and BCF files. It interacts with data from the Rule Configuration Service and Digital Specifications.
    - **Urban Regulations Compliance**: Automated compliance checks are performed based on urban regulations, supporting permit issuance for public and private works. This service integrates with the Building Permit Decision Support Service to facilitate permit granting.
- Building Permit Application Services:
    - **Messaging Service:** Assists architects in generating and submitting building permit applications. It interacts with the Building Permit Decision Support Service to ensure submissions are in the appropriate format.
    - **Information Requirements Service**: Defines and manages Information Requirements (IR) and BIM modelling guidelines used in permit applications. This service supports the Building Permit Application Checking Service by providing necessary requirements and guidelines.
    - **Application Checking Service**: Checks BIM models against predefined Information Requirements to ensure compliance with permit guidelines. It uses data from the Building Permit Information Requirements (IR) Service.

Project Environment

Industry professionals can access the latest NMCC content directly from the NRC DCP, via applications in the web services connected to the platform via API, or from municipal or provincial regulators. Content can also be collected directly if web services are not used. Professionals will submit BIM files in IFC format for regulatory review within the openCDE, receiving feedback via BCF throughout the development approvals process.

Regulatory Environment

The regulatory environments are separate common data environments that leverage the NRC Digital Construction Platform. Each regulatory CDE will include a portal and an openCDE to collaborate on the IFC submission and share comments via BCF amongst the regulatory bodies and all the government agencies. Each Regulatory Common Data Environment will follow a standard structure: Work in Progress, Shared, Published and Archive. The submitted PIM is used to populate a city information model or digital twin (CIM / DT) for a central database for reporting, managing, operating, and planning.

The Regulatory openCDE will be leveraged from pre-consultation through inspections to project completion creating a single thread of project information throughout development approvals. The published PIM Specification, Information Requirements, and IDS from NRC can be added to by the municipality for zoning and other regulatory compliance checks specific to that jurisdiction. Using the NRC Common Data Framework and expanding on the NRC Digital Construction Platform allows for a wholistic approach to regulatory reviews.

Provincial and regional codes adapt NMCC for their needs and publish to the NRC DCP. PIM specifications and information requirements for automated code compliance will be available from NRC. Government agencies developing provincial or regional codes will make these documents available on the NRC DCP to centralize access.

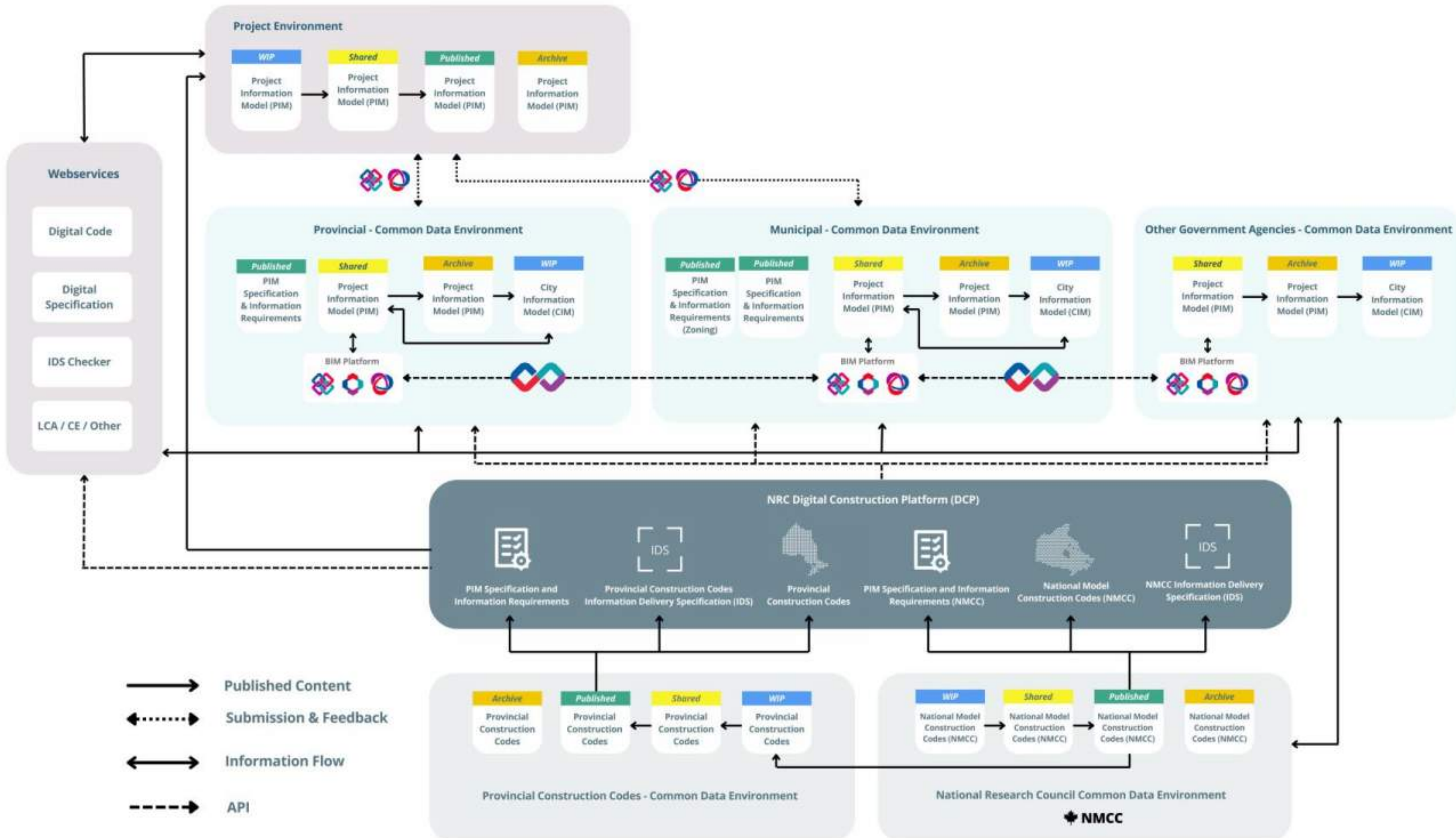


Figure 24 Detail diagram of the NMCC connection to the NRC Digital Construction Platform

4.4.1.1. NMCC Requirements

The following requirements have been identified to enable the integration of the NMCC into the DCP. These requirements support the integration of NMCC into the NRC DCP by ensuring digitization, standardization, accessibility, security, and usability of the NMCC content within the NRC's digital platform. This holistic approach allows various stakeholders to interact with the NMCC content efficiently and effectively within the NRC DCP.

The NRC DCP is a collection of information from different departments within NRC as well as other government agencies. The platform is primarily used to share information outward, however, there is a small portion that allows for submissions and feedback to come to NRC. Centralizing many separate regulatory documents and resources allows for much more linking and cross-referencing.

Each NRC department (NMCC, CCMC, and NMS) also require collaboration and information exchange, each Common Data Environment will be connected via APIs to allow for more seamless exchange and increase cross-sector communication.

Table 10 NMCC requirements

Requirement	Description	Stakeholders Involved
Digital Content Management	Digitize NMCC content using machine-readable formats and structured data representations to ensure accessibility and standardization. This includes PIM Specifications and Information Requirements for automated code checking.	Architects & Engineers, Builders, Manufacturers & Business Interests
Rule Configuration Service	Develop a service to manage and update rule sets based on current specifications and regulations. This service supports various compliance checking services, including automated code checks and BIM viewer integration.	Government Regulatory Bodies, Third-Party Developers
Compliance Checking Services	Develop services for Land Use, Building Permit, and Urban Regulations Compliance. This includes automated code checking, BIM viewers, compliance reports, and BCF files, with interactions from the Rule Configuration Service and Digital Specifications.	Architects & Engineers, Builders, Government Regulatory Bodies, Third-Party Developers
Information Requirements Service	Define and manage Information Requirements (IR) and BIM modelling guidelines for permit applications. This service supports the Building Permit Application Checking Service and ensures compatibility with automated code checks.	Architects & Engineers, Builders, Third-Party Developers
Web Services and API Connectivity	Provide third-party vendors and regulatory bodies with secure and real-time access to the latest NMCC content via the NRC DCP. Includes Digital Code	Third-Party Developers, Government Regulatory Bodies

Requirement	Description	Stakeholders Involved
	Management, Rule Configuration, and other web services.	
Project and Regulatory Environment	Provide a comprehensive environment for accessing NMCC content, regulatory reviews, and project activities. Enable IFC format BIM file submissions for regulatory review within the openCDE, with feedback via BCF. Includes a central database for reporting and planning.	Architects & Engineers, Builders, Government Regulatory Bodies
Land-Use Plans Conversion Service	Create a service to convert land-use plans into standardized formats compliant with OGC geospatial encoding rules. This standardized data is used for Land Use Compliance Checking.	Government Regulatory Bodies, Third-Party Developers
Provincial and Regional Codes	Adapt NMCC content for provincial or regional needs and publish it to the NRC DCP. Ensure PIM specifications and Information Requirements for automated code compliance are available. Government agencies developing provincial or regional codes will also publish to NRC DCP.	Government Regulatory Bodies
Collaboration and Feedback	Enable collaboration among regulatory bodies and agencies via openCDE, supporting IFC submissions and BCF feedback. Create a single project information thread from pre-consultation to project completion.	Government Regulatory Bodies
Data Standardization and Exchange	Promote data standardization and exchange using openCDE API connections. Ensure compliance with relevant standards for seamless integration and interoperability across different CDEs.	Government Regulatory Bodies, Third-Party Developers
Training and Support	Provide training programs, user guides, and support services for industry professionals, regulatory bodies, and third-party vendors. Facilitate adoption and effective use of the NMCC and CDP environments.	Architects & Engineers, Builders, Building Owners, Operators, Government Regulatory Bodies, Third-Party Developers
Security and Access Control	Implement robust security measures and access control protocols to protect NMCC content and ensure only authorized users access to sensitive information.	All Stakeholders
Version Control and Archiving	Ensure proper version control and archiving of NMCC content, allowing access to both current and historical versions of building codes and related documents.	All Stakeholders
Centralized Reporting and Analytics	Develop centralized reporting and analytics tools for decision-making, compliance tracking, and performance monitoring across the NMCC and CDP environments.	Government Regulatory Bodies, Architects & Engineers, Builders, Building Owners,

Requirement	Description	Stakeholders Involved
		Operators, Environmental Groups
Integration with Existing Systems	Ensure seamless integration with existing systems and platforms used by industry professionals and regulatory bodies. Minimize disruption and facilitate a smooth transition.	Architects & Engineers, Builders, Government Regulatory Bodies, Third-Party Developers
User-Friendly Interface	Design a user-friendly interface for accessing NMCC and DCP environments. Ensure ease of use and efficiency for industry professionals, regulatory bodies, and third-party vendors.	All Stakeholders

4.4.2. NMS User Scenarios

NMS (Figure 25) will leverage the NRC DCP to publicly share its content with industry professionals and third-party software providers. The NMS CDE will connect with other government agencies to gather information and may use third-party applications for tasks within the NRC NMS CDE. The more detailed components of NMS in connection to NRC DCP is shown in Figure 26.

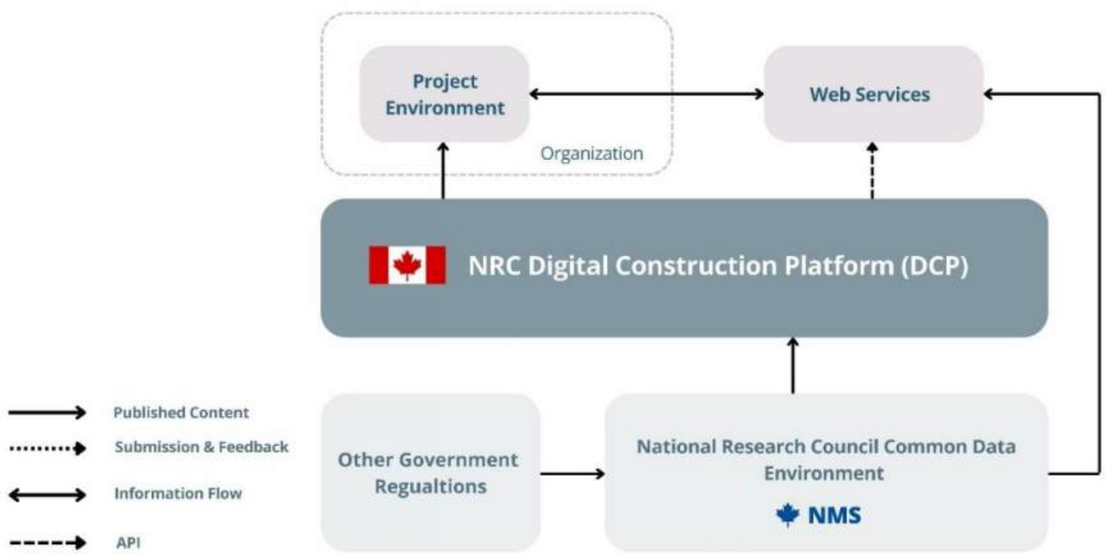


Figure 25 Overview of the NMS connection to the NRC Digital Construction Platform

Web Services

Third-party vendors can access the latest published NMS content from the NRC DCP for use in their applications and services. These web services can be accessed independently and may have API connections to the platform, providing feedback capabilities to the NRC NMS CDE. More specifically, Digital Specifications Services connect to third-party platforms to import and utilize standardized specifications and codes. This service provides the foundational data that underpins various functions, including compliance checking and rule application.

Organizations

Industry professionals can access the latest NMS content directly from the NRC DCP or via applications connected through API. At an organizational level, a 'tailored' NMS can be customized per project.

Project Environment

Professionals can access the latest NMS content directly from the NRC DCP or through connected applications. If an organization uses a 'tailored' NMS version, it will be modified per project requirements.

Other Government Agencies

Other government agencies will work within their own CDEs and share regulatory publications with the NRC CDE, which NRC may publish upon agreement.

NRC NMS Common Data Environment

The NRC NMS CDE will follow a standard structure: Work in Progress, Shared, Published, and Archive. Once NMS content is published, it is pushed to the NRC DCP, with archived copies kept. Web services are accessible via the NRC DCP.

NRC Digital Construction Platform

Approved NMS content is moved to the NRC DCP (Figure 25). Within the platform, NMS content may be linked to referenced codes or regulations via hyperlinks and to other sectors of NRC's published content.

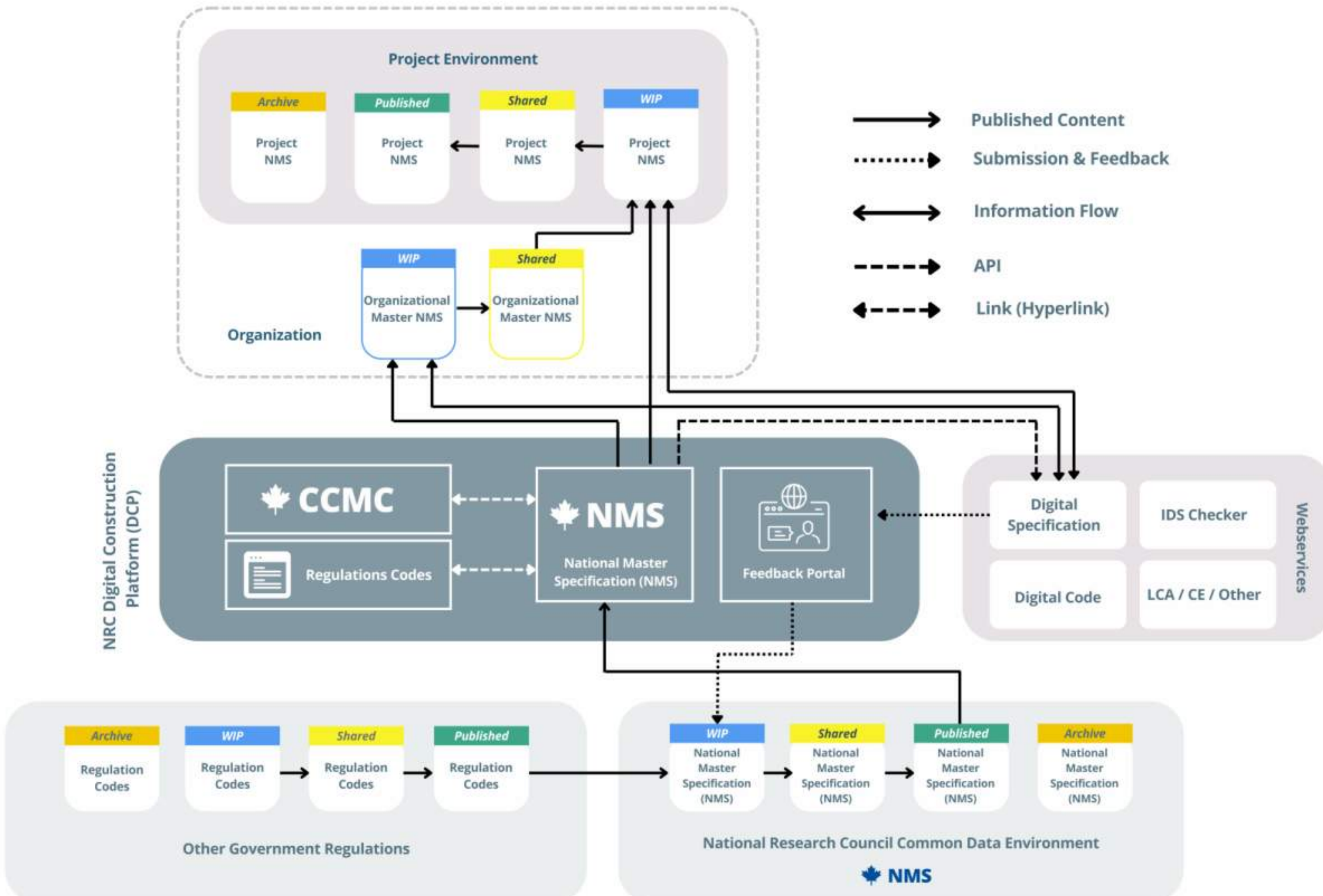


Figure 26 Detail diagram of the NMS connection to the NRC Digital Construction Platform

4.4.2.1. NMS Requirements

The requirements listed in the table below address the integration of NMS into the NRC DCP. They cover essential aspects such as NMS content development, curation, standardization, user access, and feedback mechanisms, ensuring a seamless and effective integration process. The NRC DCP serves as the overarching system that hosts and provides access to the curated NMS content after it has been developed and processed within the NMS CDE.

Table 11 NMS Requirements

Requirement	Description	Stakeholders Involved
Digital Content Integration	Ensure NMS content is digitalized and available in machine-readable formats. This aligns with digitalization goals and ensures compatibility with digital systems and tools.	NMS Technical Team, Content Developers, NRC Digital Platform Team
Content Development Process	Develop and update NMS content through structured processes involving industry experts. This supports effective content management and updates, maintaining accuracy and relevance.	NMS Content Developers, Industry Experts, NRC Technical Team
Curated Content Management	Implement review and update mechanisms to maintain NMS content quality. It ensures quality and consistency of NMS content are in line with digital resource management requirements.	NMS Technical Team, National Advisory Board
Standardized CDE Structure	Use a standardized structure for NMS CDE: Work in Progress, Shared, Published, and Archive. It provides clarity in content lifecycle management and aligns with standard CDE structure requirements.	NRC CDE Administrators, NMS Technical Team
Feedback Mechanism	Facilitate feedback through the portal for continuous improvement. It enhances content quality and allows for continuous improvement based on user feedback.	Industry Professionals, Third-party Vendors, NRC Technical Team
Compliance Checking and Rule Application	Integrate compliance and rule application functions with standardized specifications. It supports adherence to standards and regulations, integrating with compliance features.	Regulatory Bodies, Industry Professionals, NMS Developers
User Interfaces (Web Services)	Provide user-friendly web interfaces for accessing NMS content and services. It ensures accessibility and usability of NMS content through digital services.	All Stakeholders
Access to Latest NMS Content	Ensure stakeholders can access the latest NMS content with version control. It keeps users updated with current content, supporting effective resource utilization and decision-making.	Industry Professionals, Organizations
Resource and Template Availability	Offer resources and templates to support NMS content utilization. It enhances usability and	Specification Writers, Architects, Engineers

Requirement	Description	Stakeholders Involved
	application of NMS content through supporting materials.	
Customization of NMS for Projects	Allow customization of NMS content per project requirements. It provides flexibility for project-specific needs while maintaining standardization across projects.	Project Managers, Architects, Construction Specialists
Digital Specifications Services Integration	Integrate NMS with third-party platforms for standardized specifications and codes. It enhances functionality by connecting with external systems and applications, supporting integration goals.	Third-party Vendors, NMS Technical Team
Independent Web Services Accessibility	Ensure content and services are accessible via robust web services with API connections. It provides flexibility and secure access to NMS content, supporting the digital platform's integration.	Third-party Vendors, Industry Professionals
Integration with NRC DCP	Automate workflows for pushing NMS content to NRC DCP and linking to other content. It streamlines content availability and integration within NRC's broader platform, supporting comprehensive data management.	NRC CDE Administrators, Regulatory Bodies
Collaboration with Other Government Agencies	Facilitate information sharing and regulatory publication exchange. It promotes broader use and compliance across agencies, aligning with collaborative goals.	Government Agencies, NRC CDE Administrators
Content Publishing Workflow	Implement a workflow for moving content through the NMS CDE stages. It ensures organized management and accessibility of NMS content throughout its lifecycle.	NRC CDE Administrators, NMS Technical Team
Data Security and Privacy	Implement robust security measures for NMS data, including encryption and access control. It protects sensitive information and ensures compliance with data protection regulations.	NRC IT Security Team, Data Privacy Officers
Scalability and Performance	Ensure the NRC DCP can handle large volumes of data and users without performance issues. It supports future growth, and scalability needs of the digital platform.	NRC Digital Platform Team, IT Performance Engineers
User Training and Support	Provide training and support resources to effectively use NMS content and NRC DCP. It ensures stakeholders are equipped to fully leverage the platform's capabilities.	All Stakeholders
Monitoring and Analytics	Implement tools to track usage patterns, performance, and feedback. It provides insights for continuous improvement and user satisfaction.	NRC Technical Team, Project Managers

Requirement	Description	Stakeholders Involved
Change Management	Develop a process for handling updates and modifications to NMS content and NRC DCP features. It ensures smooth updates and minimizes disruptions during changes.	NRC Change Management Team, NMS Technical Team

4.4.3. CCMC User Scenarios

CCMC will utilize the NRC Digital Construction Platform (NRC DCP) to publicly share its content with manufacturers, industry professionals, and third-party software providers (Figure 27). The CCMC CDE will connect with other government agencies to gather necessary information, i.e., regulations codes, and may use third-party applications for various tasks within the NRC CCMC CDE. The more detailed components of CCMC in connection to NRC DCP is shown in Figure 28.

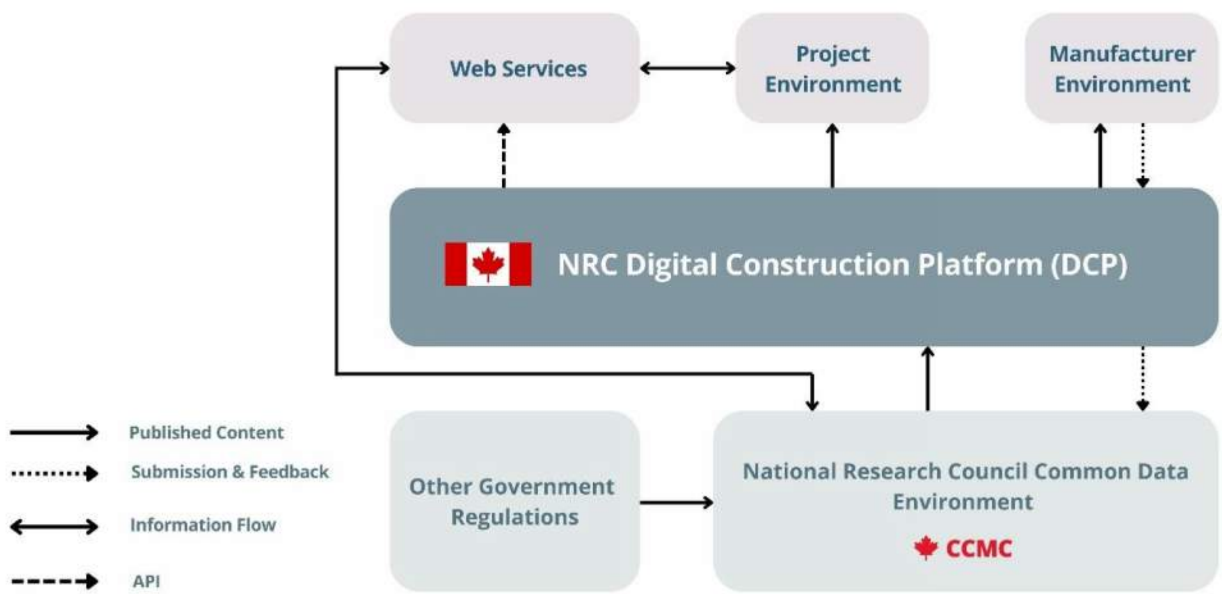


Figure 27 Overview of the CCMC connection to the NRC Digital Construction Platform

Web Services

Third-party vendors can access the latest published content from the NRC DCP for use in their applications and services, which serve NRC, other government agencies, and industry professionals. These web services can be accessed independently from the NRC DCP and may have API connections to the platform. Examples of services from the CCMC include Material passports, Product data templates, services relating to Circular Economy in the construction sector as well as LCA/LCCA (see below).

Project Environment

Industry professionals can directly access the latest CCMC content from the NRC DCP or through applications connected to the platform via API. Both industry professionals and NRC can utilize the CCMC content either directly from the platform or through the web services.

Manufacturer Environment

Manufacturers submit material applications to NRC via the NRC DCP Submission Portal. These applications will be processed within the NRC CDE while leveraging the NRC DCP for collaboration and feedback.

Other Government Agencies

Other government agencies will operate within their own CDEs and share regulatory publications with the NRC CDE. By mutual agreement, NRC will publish these shared publications.

NRC CCMC Common Data Environment

The NRC CCMC CDE will follow a structured approach: Work in Progress, Shared, Published, and Archive. Once CCMC content reaches the Published state, it is pushed to the NRC DCP, with archived copies kept. Web services are also accessible via the NRC DCP.

NRC Digital Construction Platform

Approved CCMC content is moved to the NRC DCP (Figure 27). Within the platform, CCMC content may be linked to referenced codes or regulations via hyperlinks and to other sectors of NRC's published content.

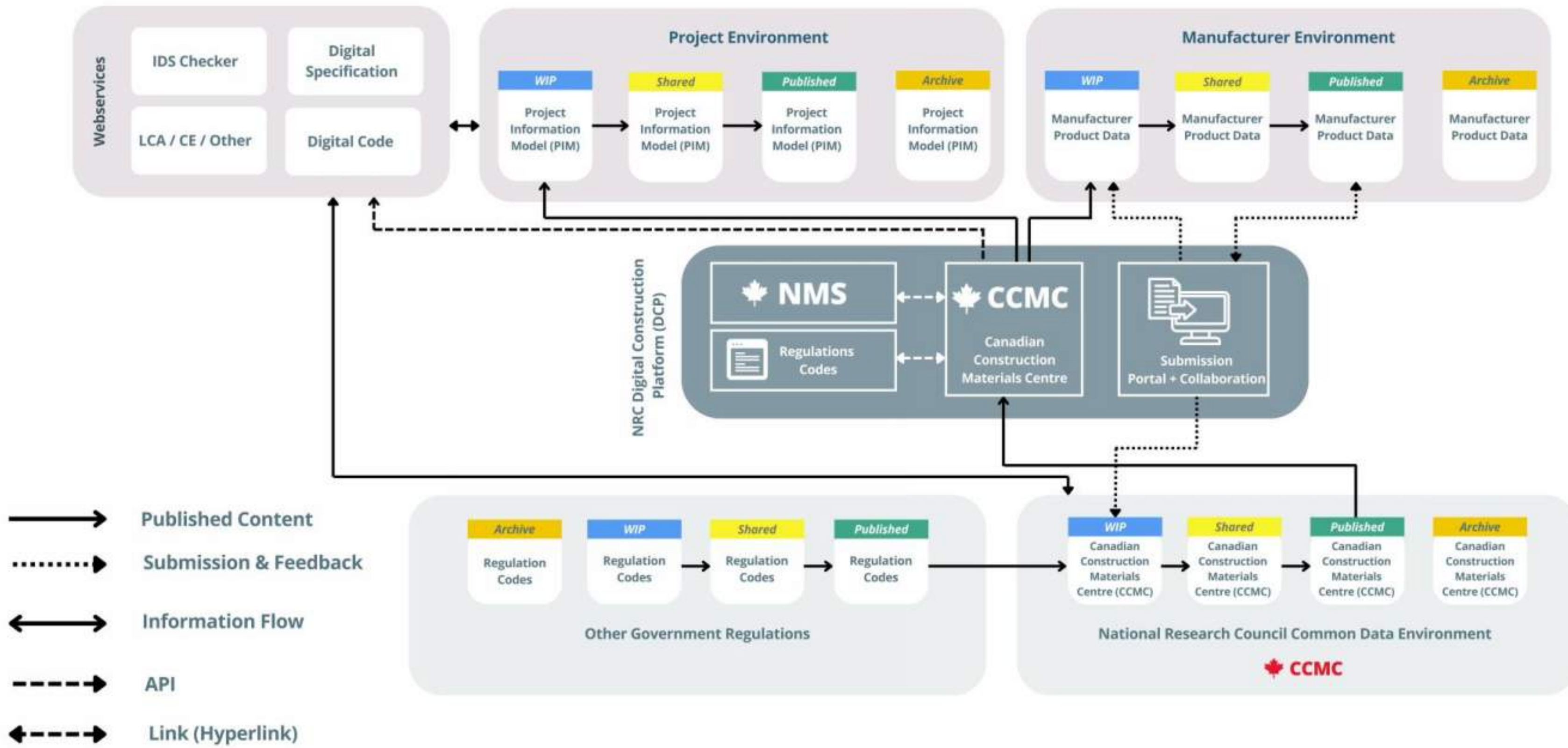


Figure 28 Detail diagram of the CCMC connection to the NRC Digital Construction Platform

4.4.3.1. CCMC Requirements

The following requirements have been identified to enable the integration of the CCMC into the DCP:

Table 12 CCMC Requirements

Requirement	Description	Stakeholders Involved
CCMC Content Integration	CCMC content, including material passports and product data templates, must be integrated into the NRC DCP. This ensures that the latest CCMC assessments and product data are accessible to industry professionals and regulatory bodies.	CCMC, NRC, Industry Professionals, Regulatory Bodies
Web Services and API Access	Provide third-party vendors with API access to the latest published CCMC content via the NRC DCP. This includes material passports, product data templates, and services related to Circular Economy and LCA/LCCA.	Third-Party Developers, Industry Professionals, NRC, CCMC
Project Environment Access	Allow industry professionals to access CCMC content directly from the NRC DCP or through connected applications. Ensure seamless interaction between the CCMC CDE and the NRC DCP for real-time updates and data access.	Industry Professionals, NRC, CCMC
Manufacturer Submission Portal	Implement a submission portal for manufacturers to submit material applications to NRC via the NRC DCP. Ensure these submissions are processed within the NRC CDE, allowing for collaboration and feedback through the platform.	Manufacturers, NRC, CCMC
Regulatory Publications Sharing	Facilitate the sharing of regulatory publications between CCMC and other government agencies. Ensure that shared publications are integrated and published through the NRC DCP, following mutual agreements.	Government Agencies, NRC, CCMC
Structured CCMC CDE	Organize the NRC CCMC CDE into structured states: Work in Progress, Shared, Published, and Archive. Ensure that CCMC content transitions through these states before being pushed to the NRC DCP, with archived copies maintained.	CCMC, NRC
Linkage to Referenced Codes	Ensure CCMC content within the NRC DCP includes hyperlinks to referenced codes or regulations and links to other NRC published content for comprehensive access and cross-referencing.	CCMC, NRC
Committee Integration	Ensure that CCMC's committees (Stakeholder, Scheme, Appeals, Impartiality) are integrated into the	CCMC Committees, NRC

Requirement	Description	Stakeholders Involved
	NRC DCP workflow for relevant assessments and decision-making processes.	
Feedback Mechanism	Implement a feedback mechanism within the NRC DCP for manufacturers and other stakeholders to provide input and receive responses related to CCMC content and assessments.	Manufacturers, Industry Professionals, CCMC
Collaboration with Other CDEs	Ensure interoperability with other CDEs used by government agencies and industry stakeholders. Facilitate data exchange and integration between CCMC CDE and other CDEs to support comprehensive regulatory and industry interactions.	Government Agencies, Third-Party Developers, Industry Professionals
Access Control and Security	Implement robust access control and security measures for CCMC content on the NRC DCP, ensuring that sensitive information is protected, and only authorized users have access to specific data.	All Stakeholders
Training and Support	Provide training and support to users involved with the CCMC content and integration with NRC DCP. Develop user guides and training programs to ensure effective utilization of the platform.	CCMC, NRC, Industry Professionals, Government Agencies
Version Control and Archiving	Ensure proper version control and archiving for CCMC content within the NRC DCP. Maintain historical versions of assessments and updates to provide a complete record of changes and revisions.	CCMC, NRC
Centralized Reporting and Analytics	Develop reporting and analytics tools to track usage, interactions, and feedback related to CCMC content within the NRC DCP. Provide insights for ongoing improvement and decision-making.	NRC, CCMC, Industry Professionals, Government Agencies
User Interface Design	Design an intuitive and user-friendly interface for accessing CCMC content and services on the NRC DCP. Ensure ease of navigation and usability for all stakeholders.	All Stakeholders

4.4.4. Other user scenarios

Other user scenarios include analytical tools and processes such as LCA as well as overall quality assurance and quality control mechanisms. **Analytical tools and processes include** software tools and platforms that facilitate LCA and other environmental impact assessments, as well as other types of analysis (including structural, acoustic, lighting, energy, etc.) ensuring they integrate seamlessly with NRC DCP. Specifically, LCA, based on the work undertaken in the LCBE as well as established standards and methodologies such as ISO 14040 series and EN 15978, and EN 15804 (Sustainability of Construction Works - Environmental Product Declarations), which provide guidelines for assessing the environmental impacts of buildings and construction activities as well as the current work underway within NRC, should be considered. Indeed, the LCBE aims to promote the development and adoption of low-carbon construction materials. Here, the CCMC's expertise in assessing construction products can play a crucial role. By integrating CCMC assessments with the LCBE program, the NRC can:

- **Identify and Validate Low-Carbon Materials:** Manufacturers of innovative low-carbon materials can leverage the CCMC assessment process to demonstrate their product's performance and compliance with relevant codes. This validation can increase industry confidence and accelerate the adoption of these materials.
- **Develop Assessment Criteria for Low-Carbon Properties:** The CCMC, in collaboration with the LCBE program, can establish specific criteria for assessing the embodied and operational carbon footprint of construction materials. This would provide a standardized method for evaluating the environmental impact of new materials.

Leveraging Existing NMS Digitalization: The existing NMS digitalization efforts can inform and complement the CSDP's development of digital portals.

In addition to automated building code checks, automated zoning checks when there is integration of BIM and GIS is possible by municipalities, this creates a more thorough compliance review that can address regulatory requirements throughout the development approvals process. Adding additional automated checks extends the same processes and infrastructure to a broader set of regulatory reviews that can also be conducted at more frequent intervals. PIM specifications will also need to be extended and built from the same framework NRC has developed but is managed locally by the municipality.

4.4.4.1. Other Requirements

Table 13 outlines additional requirements that are integral to the successful implementation of the NRC’s DCP and the requirements were derived through a comprehensive analysis of the NRC's current operational landscape, the goals of DCP, and the critical needs of the Canadian built asset industry. These requirements were highlighted as they represent fundamental elements necessary to ensure the effective implementation and functionality of the DCP. Their importance lies in their role in enabling interoperability across various digital tools and platforms, ensuring regulatory compliance, supporting sustainable construction practices, and facilitating the digitalization of key NRC resources such as NMCC, NMS, and CCMC evaluations. By addressing these requirements, the DCP aims to create a cohesive, efficient, and sustainable digital ecosystem that meets the evolving needs of the industry.

Table 13 Other NRC DCP Requirements

Requirement	Description	Stakeholders Involved
Integration of Analytical Tools	Integrate various analytical tools into NRC DCP, including those for LCA, structural analysis, acoustic analysis, lighting analysis, and energy analysis. Ensure these tools adhere to standards like ISO 14040, EN 15978, and EN 15804 for comprehensive environmental impact assessments.	NRC, Software Providers, Industry Professionals
Enhanced Quality Assurance and Control	Implement robust quality assurance and control mechanisms to monitor and validate the performance of analytical tools and processes. This includes regular audits, automated validation checks, and user feedback integration.	NRC, Quality Assurance Teams, Industry Professionals
Automated Zoning Checks	Develop and integrate automated zoning checks within the NRC DCP by incorporating BIM and GIS technologies. This will enable municipalities to conduct thorough compliance reviews, addressing regulatory requirements throughout the development approvals process.	Municipalities, NRC, Software Providers
Extended IM Specifications	Extend IM (Information Model) specifications to support automated zoning checks and local management by municipalities. Ensure that the extensions align with the NRC framework while allowing for local regulatory needs.	Municipalities, NRC, Software Providers
Standardized Environmental Impact Assessment	Develop standardized methods for assessing the environmental impact of construction materials and activities, including embodied and operational carbon footprints. This should align with LCBE and other relevant initiatives.	NRC, LCBE Program, Industry Professionals
Low-Carbon Materials Validation	Enable the validation of low-carbon construction materials through the NRC DCP, leveraging CCMC's expertise. Develop specific criteria for assessing low-carbon properties and integrate this validation into the NRC's broader digital framework.	CCMC, NRC, LCBE Program, Manufacturers
Digital Portal Development	Utilize existing NMS digitalization efforts to enhance the development of digital portals and systems within the NRC DCP. Ensure that these portals support seamless integration with other digital tools and initiatives.	NRC, NMS Program, Software Providers
Comprehensive Reporting	Implement comprehensive reporting tools within NRC DCP to support the new analytical processes, zoning checks, and quality assurance measures. Provide detailed insights into compliance, performance, and impact.	NRC, Software Providers, Industry Professionals

Requirement	Description	Stakeholders Involved
Interoperability with External Systems	Ensure interoperability of NRC DCP with external systems and tools, including those used for environmental impact assessments and zoning checks. Facilitate seamless data exchange and integration.	NRC, Software Providers, Industry Professionals
User Training and Support	Develop training programs and support resources for users to effectively utilize new analytical tools, automated checks, and quality assurance features within the NRC DCP. Provide user guides, workshops, and help desks.	NRC, Software Providers, Industry Professionals
Continuous Improvement Mechanism	Establish a mechanism for ongoing evaluation and improvement of the NRC DCP's analytical tools, automated checks, and quality assurance processes. Incorporate user feedback and emerging best practices to enhance functionality and effectiveness.	NRC, Quality Assurance Teams, Industry Professionals

This section has laid out the key concepts and frameworks underlying the NRC's DCP as well as the scenarios explaining how it will be deployed within the Canadian built asset industry. The delivery of the services and ecosystem supporting them is a considerable task that requires a long-term vision and commitment. A number of stakeholders will have to come together, under the leadership of the NRC, to plan, deliver, test and deploy the DCP. This will have to be done in a systematic and iterative way. The next section lays out the roadmap that is proposed to deliver the DCP.

5. DCP R&D Roadmap

The proposed DCP R&D Roadmap is structured across three streams each articulating three sub-streams. The activities and milestones are defined according to these sub-streams. The three steams and nine sub-streams, including their aims, are described in Table *14***Error! Reference source not found.**. The Proposed High-level DCP R&D Roadmap is shown in *Figure 29*. The full roadmap is shown in Appendix 1 and available online.

Table 14 Roadmap streams and sub-streams and their aims

Streams / sub-streams	Aim
1. Digital Resources	To make available all NRC resources and necessary processes and frameworks for use by different stakeholders involved across the built asset lifecycle.
1.1 Digital content	To digitalize NRC's content and transition to machine readable and exchangeable formats
1.2 Supporting resources	To develop the various resources supporting the digitalization and distribution of NRCs resources
1.3 Digital processes	To formalize the processes supporting the digitalization and distribution of NRCs resources
2. Digital Platform	To develop, deliver and maintain a platform for use by different stakeholders involved across the built asset lifecycle.
2.1 Functions / services	To identify and develop the functions and services available through and supporting NRC's digital platform
2.2 Exchanges / integrations	To develop the exchange standards and protocols as well as integrations required to support NRC's digital platform
2.3 Repositories	To develop and implement the necessary repositories for data and resource curation and storage to support NRC's digital platform
3. Platform Delivery	To establish the project governance and management structures as well as the supporting actions to develop capabilities and upskill stakeholders involved across the built asset lifecycle.
3.1 Project management and governance	To structure and articulate the project management activities as well as the governance mechanisms required to properly deliver and maintain the NRC digital construction platform
3.2 Capability development	To develop the training, guidance, and standards needed to fully deploy the NRC digital construction platform
3.3 Communications	To communicate the initiative to the different stakeholders involved across the built asset lifecycle.

The Roadmap's timeline extends over a 6-year period, from 2024 to 2030, and is developed across 3 phases, each lasting between 16 and 24 months in duration. Phase I is planned from September 2024 to December 2025 (16 months) and is dedicated to preparatory work and establishing the foundational resources needed for the development of the DCP. In parallel, the project's project management and governance are put in place. Phase II is planned from January 2026 to December 2027 (24 months) and is dedicated to the development and scaling of core resources and the integrations needed to operationalize the DCP. Finally, phase III is planned from January 2028 to April 2030 (28 months) and is aimed at developing advanced features and services and further developing the ecosystem. Throughout the latter phases, project management activities as well as capability development and communications are defined and supported. It is important to note that the proposed timeframe is mainly for development purposes and that implementation will extend beyond this initial 6-year period. Six milestones are provisionally set for progressive testing and release of the DCP:

- Milestone 01: January 2026 - Launch DCP v1 - Beta
- Milestone 02: January 2027 - Launch DCP v1 - Alpha
- Milestone 03: January 2028 - Launch DCP v2 - Beta
- Milestone 04: January 2029 - Launch DCP v2 - Alpha
- Milestone 05: January 2030 - Launch DCP v3 - Beta
- Milestone 06: April 2030 - Launch DCP v3 - Alpha

Milestones 01, 03 and 06 coincide with the ends of phases I, II and III respectively. For Milestones 01 and 03, Beta versions of the DCP should be launched to test interfaces and functionalities while validating content availability and usability. The testing and improvement process for the Beta versions are slated to last one year, with the launch of Alpha versions occurring at milestones 02, 04 and 06. Alpha versions should be stable and ready for broad diffusion and use, including proper training materials and necessary resources.

From a very broad perspective, version 01 of the platform should offer the basic user interface and the capacity to connect securely to the platform. The content should be available in current formats with certain targeted content available in a machine-readable format. Version 02 should offer more advanced functionalities and more options to establish connections to the content and services. A large proportion of NRCs key resources should be digitized and available in machine-readable formats with possibilities to integrate directly into modelling software. Version 03 should offer most functionalities and host most content identified in the roadmap while providing more advanced services as they become available through the PDCSS programme.

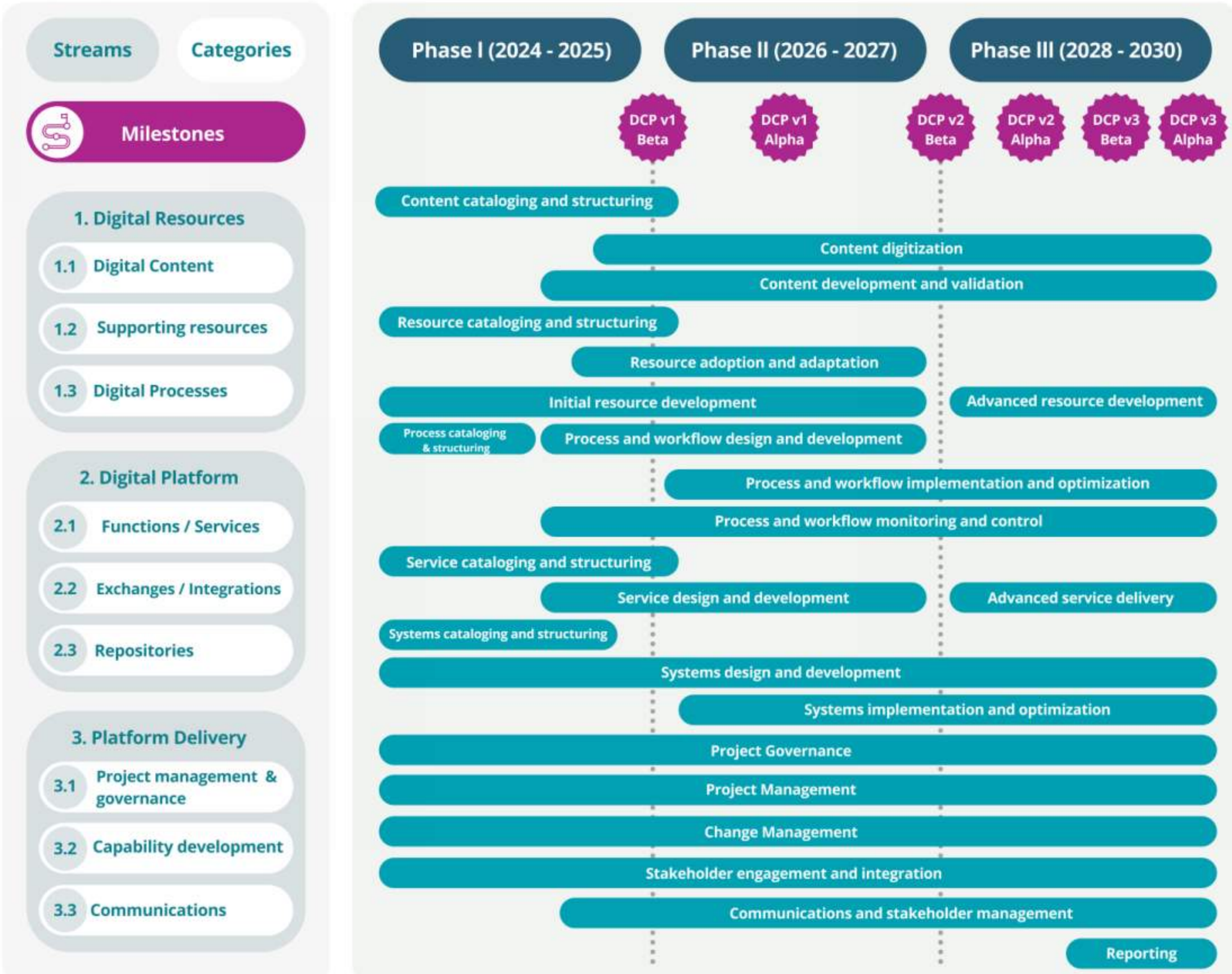


Figure 29 Proposed High-level DCP R&D Roadmap

The activities defined within the roadmap are aimed at achieving the goals and objectives laid out earlier in this document. These activities were identified and positioned across the three streams and 9 sub-streams and articulated across three phases as a result of the different workshops, assessments and discussions that were held over the course of the research project. They were also defined to meet the requirements identified in section 4.4.

A total of 198 activities are defined in the roadmap. As shown in Figure 30, the number of activities is relatively evenly distributed across all sub-streams, with an average of 20 activities per sub-stream, except for sub-streams 1.1 and 2.1, which include over 30 activities each. This is due to the fact that both these sub-streams relate to the actual content and functions/services being offered by the DCP.

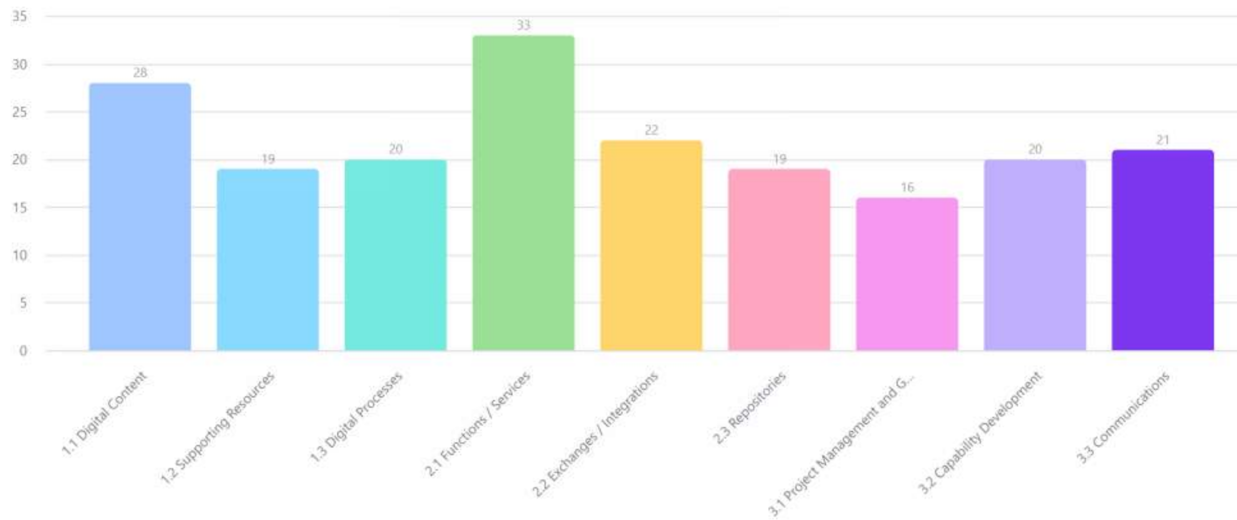


Figure 30 Distribution of activities by sub-stream

Each activity is given an approximate duration, as well as start and end dates. Duration is given for information purposes and can vary according to resource availability and overall speed of delivery. Moreover, the activities are categorized following a series of tags:

- **Stream/sub-stream:** the stream/sub-streams to which the activity belongs as defined in Table *14*. Activities can only belong to one sub-stream
- **Phase:** The phase in which the activity occurs. The three phases are described above. Certain activities can span multiple phases depending on their duration. Figure 31 shows the distribution of activities by phase.
- **Activity type:** The categorization of a specific activity to enable aggregation as shown in Figure 29. Broadly categorized, the roadmap activities fall into one of 23 activity types. Figure 32 illustrates the distribution of activities by type:
    - Content cataloguing and structuring
    - Content digitization

- Content development and validation
- Resource cataloguing and structuring
- Resource adoption and adaptation
- Advanced resource development
- Process and workflow cataloguing and structuring
- Process and workflow design and development
- Process and workflow implementation and optimization
- Process and workflow monitoring and control
- Service cataloguing and structuring
- Service design and implementation
- Advanced service delivery
- Systems cataloguing and structuring
- Systems design and development
- Systems implementation and optimization
- Project governance
- Project management
- Change management
- Stakeholder engagement and integration
- Communication and stakeholder management
- Reporting

- **CDF Resource:** The link to the CDF resources that are either called upon or created through the activity
- **User Scenario:** The scenario's requirements the activity helps meet. Some activities are related to a single scenario; however, most are applicable to all three and the DCP in general.
- **Predecessor:** Any activity that must be completed or well underway prior to a particular activity is undertaken.

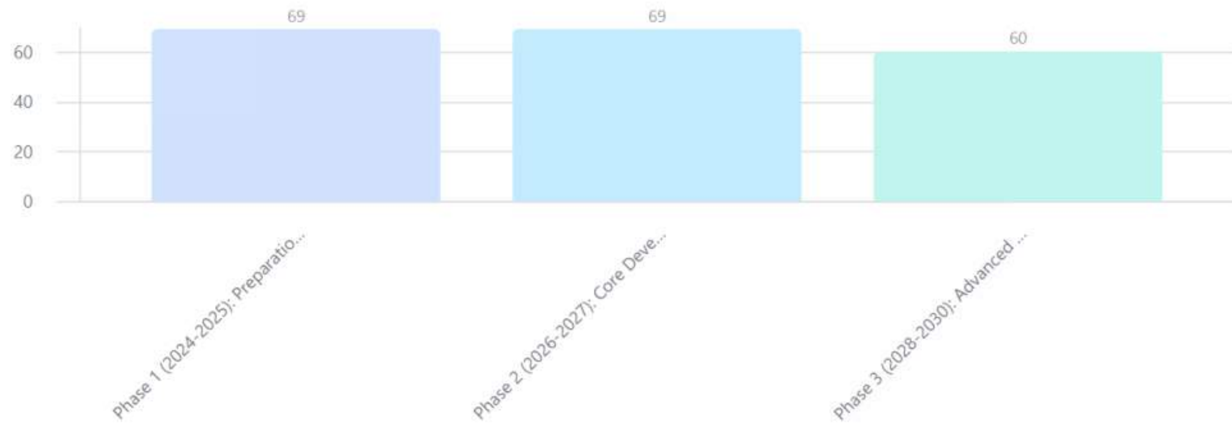


Figure 31 Distribution of activities by phase

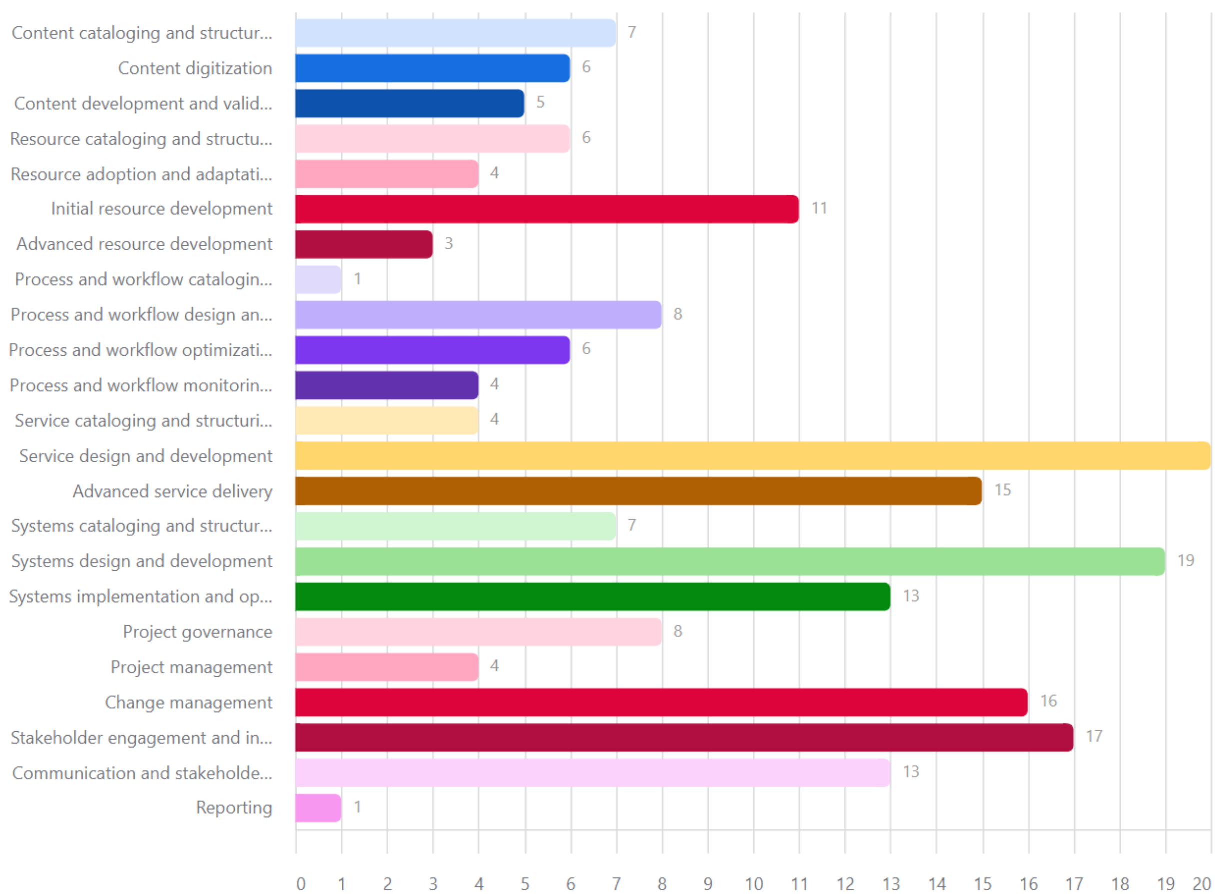


Figure 32 Distribution of activities by activity type

The success of the NRC DCP and its delivery through the roadmap is predicated upon the following conditions:

1. **Strategic Alignment**: Ensure the NRC DCP initiative remains closely aligned with the broader objectives of the Platform to Decarbonize the Construction Sector at Scale (PDCSS). Regular reviews and adjustments may be necessary to maintain this alignment as both initiatives progress.
2. **Interdepartmental Collaboration:** Foster strong collaboration between the NMCC, NMS, and CCMC departments within NRC to ensure seamless integration of their respective resources into the DCP.
3. **Industry Engagement:** Develop a comprehensive industry engagement strategy to gather ongoing feedback and ensure the DCP meets the evolving needs of the Canadian built asset industry.
4. **Regulatory Considerations:** Work closely with provincial and territorial authorities to address potential regulatory challenges and ensure the DCP supports harmonization efforts across jurisdictions.
5. **Technology Monitoring:** Establish a process for continuous monitoring of emerging technologies that could impact or enhance the DCP, ensuring the platform remains at the forefront of digital innovation in construction.
6. **International Collaboration:** Explore opportunities for international collaboration and knowledge sharing, particularly with organizations undertaking similar initiatives in other countries.
7. **Economic Impact Assessment:** Conduct a comprehensive study on the potential economic impact of the DCP on the Canadian construction industry to support ongoing investment and development.
8. **Sustainability Integration:** Ensure that sustainability and decarbonization goals are deeply integrated into all aspects of the DCP as it develops, supporting Canada's broader environmental objectives.
9. **Long-term Sustainability Plan:** Begin developing a long-term sustainability plan for the DCP, considering future funding models, governance structures, and evolution beyond the initial implementation period.

6. Conclusion and Next Steps

This document presented the NRC's proposed DCP, its positioning, structure and defines a roadmap to deliver it over the next 6 years. The NRC DCP is to be delivered as part of the CSDP, which aims to develop and promote digital tools and technologies as well as other innovative project delivery approaches as part of the NRC's Platform to Decarbonize the Construction Sector at Scale (PDCSS). The PDCSS ultimately supports the development and deployment of low-carbon construction solutions across the country, while improving regulatory compliance, and driving digital innovation.

The NRC'S DCP is a response to the Canadian built asset industry's notorious challenges as they relate to productivity, decarbonization, and innovation, among others. More specifically, the CSDP highlights the need for standardized, machine-readable formats for construction codes, specifications, and product data, the importance of interoperability and seamless data exchange between different stakeholders and systems, the potential for automated compliance checking and e-permitting streamlining regulatory processes. The significant efforts to support decarbonization in the construction sector. As such, the DCP is designed to:

- **Enhance productivity and efficiency** through streamlined workflows, automated processes, and improved data management.
- **Improve decision-making** by providing access to real-time data and analytics for informed decision-making.
- **Increase sustainability** by supporting low-carbon construction practices and lifecycle assessment.
- **Enhance regulatory compliance** with simplified building permit processes and automated compliance checks.

This is to be achieved through the DCP by setting a foundation for improved data management systems, enhanced BIM compatibility, CDE interoperability, and integrated API connections for seamless information exchanges among the different stakeholders within the Canadian built asset industry. The success of the DCP is predicated upon the integration of the NMCC, NMS, and the content published by CCMC such as its evaluations into a unified digital ecosystem which will significantly enhance accessibility and utility for stakeholders across the industry.

To articulate the vision and develop a roadmap for its implementation, the NRC called upon a team led by buildingSMART Canada, supported by researchers from ÉTS. The objective of the research project was to develop an R&D roadmap to deliver the NRC DCP. The sub-objectives of the NRC DCP project were:

1. To develop a robust digital infrastructure that supports the management and dissemination of construction codes, standards, and specifications in digital and machine-readable formats.
2. To enhance interoperability among various digital tools and platforms used by industry professionals, regulatory bodies, and government agencies.
3. To promote sustainability through the integration of decarbonization strategies within the construction sector.
4. To streamline regulatory compliance processes using automated tools and enhanced collaboration features.
5. To promote and enable collaboration across NRC departments while centralizing and ensuring access to key resources.
6. To establish a foundational architecture and resource pool for the development of interoperable platforms and software tools within the Canadian built asset industry.

The research project has led to two key deliverables: The DCP framework, which includes the Common Data Framework (CDF) and the Common Data Environments (CDE), which identify the necessary data structures, exchange mechanisms, and advanced processing capabilities to support broad digitalization, the identification of user scenarios, and the R&D roadmap. The NRC DCP initiative aligns with and builds upon international efforts, around digital and BIM-enabled permitting, material databases, and digital specifications. The DCP is designed to address the diverse needs of government agencies, industry professionals, manufacturers, and regulatory bodies, promoting collaboration and interoperability across the sector.

The proposed roadmap spans a six-year period and is divided into three phases. Divided into three streams and nine sub-streams, it provides a structured and manageable approach to developing and implementing the DCP, allowing for iterative improvements and stakeholder feedback. Indeed, the proposed phased approach ensures a systematic development process, aligning closely with the strategic objectives of the NRC DCP. The objective is to demonstrate technological feasibility, foster robust stakeholder collaboration, and support sustainable construction practices. By adhering to open standards, the NRC's DCP promotes consistency and cooperation across industry stakeholders. This integration of elements is designed to drive digital transformation within the Canadian built asset industry, enhancing data management, collaboration, and operational efficiency.

It is important to note that while not specifically addressed in this report, emerging technologies such as digital twins, distributed ledger technology, and artificial intelligence are considered through the scalable and modular structure of the DCP framework. Certain activities in the roadmap relate to these technologies, however, more work will be required to ensure that they be properly integrated into the overall DCP initiative.

Next Steps:

The initiative's next steps, part of which are identified in the DCP roadmap, are discussed below. These should be prioritized in the weeks following acceptance of the report:

1. **Allocate the necessary resources:** Secure necessary resources and funding for the development and implementation of the DCP over the proposed 6-year timeline.
2. **Collaboration and partnerships:** Pursue partnerships with other government agencies, academic institutions, and industry leaders to leverage expertise and ensure the DCP's relevance and effectiveness.
3. **Establish Governance Structure** (activity 3.1.01): Immediately form a steering committee and working groups to oversee the project's implementation, ensuring alignment with the PDCSS objectives and industry needs.
4. **Initiate Foundational Work** (activities 1.1.01, 1.1.02, 1.1.05, 1.1.07, 1.1.12): Begin the comprehensive audit of existing NRC content and identify machine-readable format requirements for each resource type. This will set the stage for the digitization process.
5. **Stakeholder Engagement** (activity 3.3.01): Develop and implement a comprehensive stakeholder engagement plan to ensure buy-in and collaboration from all relevant parties throughout the development process.
6. **Technical Infrastructure Development** (activities 2.3.01, 2.3.02): Initiate the design and implementation of the core digital infrastructure, including data repositories, API frameworks, and integration mechanisms.
7. **Capability Development** (activity 3.2.01): Conduct a skills assessment of NRC staff and develop training plans to address identified gaps, ensuring the organization has the necessary expertise to support the DCP's development and operation.
8. **Pilot Projects**: Initiate pilot projects for key components of the DCP, particularly in areas such as digital code compliance checking and e-permitting, to test concepts and gather early feedback.
9. **Continuous Evaluation and Adaptation** (activity 3.1.07): Establish mechanisms for ongoing evaluation of the DCP's development, allowing for agile adaptation to emerging technologies and changing industry needs.
10. **Long-term Strategy Development** (activity 3.1.03): Begin formulating a long-term strategy for the DCP's evolution beyond the initial implementation period, considering potential expansions of functionality and scope.
11. **Communication Strategy** (activity 3.3.02): Develop and implement a comprehensive communication strategy to keep all stakeholders informed of progress, milestones, and opportunities for involvement throughout the DCP's development.

By instantiating a robust plan informed by the R&D roadmap and maintaining a flexible and collaborative approach, the NRC can successfully deliver its DCP that will drive significant improvements in productivity, sustainability, and innovation across the Canadian built asset industry. The NRC DCP has the potential to significantly impact how the industry approaches the planning, delivery, management and use of the built environment, with far-reaching implications for efficiency, regulatory compliance, and environmental sustainability in the construction sector.

References

Al-Doori, M., Breitenfelder, K., Berlo, L. van, Tomczak, A., Zaborowski, P., Keberle, N., Mattila, I., Makkinga, R., Beach, T., & Costa, G. (2024). *Technical Requirements Elicitation, Analysis and Cloud Architecture Model* (D4.1; ACCORD - Automated Compliance Checks for Construction, Renovation or Demolition Works). European Union. https://accordproject.eu/wp-content/uploads/2024/03/ACCORD_D4.1_Technical-Requirements-Elicitation-Analysis-and-Cloud-Architecture-Model.pdf

BCA. (2021). *CDE Data Standard*. BCA Corp. https://www1.bca.gov.sg/buildsg/digitalisation/cde-data-standard

BIM Dictionary. (2022). *BIM Dictionary*. https://bimdictionary.com/

Bolpagni. (2016). *The Many Faces of 'LOD.'* BIM ThinkSpace. https://www.bimthinkspace.com/2016/07/the-many-faces-of-lod.html

Breitenfelder, K., Lavikka, R., Mäkeläinen, T., Hradil, P., Kiviniemi, M., Raitviir, C.-R., Beach, T., Cheung, F., Costa, G., Mattila, I., & Morilla, M. (2023). *ACCORD Framework and User Requirements Specification* (1.2; ACCORD - Automated Compliance Checks for Construction, Renovation or Demolition Works). European Union. https://accordproject.eu/wp-content/uploads/2023/09/ACCORD_D1.2_ACCORD-Framework-and-User-Requirements-Specification.pdf

bSI. (2024). *Home | Use Case Management*. https://ucm.buildingsmart.org/

bsi. (2024). *What is Information Delivery Specification (IDS)—buildingSMART International*. https://www.buildingsmart.org/what-is-information-delivery-specification-ids/

bSI. (2024). *buildingSMART/OpenCDE-API* [Makefile]. buildingSMART. https://github.com/buildingSMART/OpenCDE-API (Original work published 2019)

Canada, N. R. C. (2019a, March 4). *Canadian Construction Materials Centre*. https://nrc.canada.ca/en/certifications-evaluations-standards/canadian-construction-materials-centre?overridden_route_name=entity.node.canonical&base_route_name=entity.node.canonical&page_manager_page=node_view&page_manager_page_variant=node_view-panels_variant-1&page_manager_page_variant_weight=-9

Canada, N. R. C. (2019b, April 2). *Canadian National Master Construction Specification*. https://nrc.canada.ca/en/certifications-evaluations-standards/canadian-national-master-construction-specification?overridden_route_name=entity.node.canonical&base_route_name=entity.node.can

onical&page_manager_page=node_view&page_manager_page_variant=node_view-panels_variant-1&page_manager_page_variant_weight=-9

Canada, N. R. C. (2023, May 1). *Platform to Decarbonize the Construction Sector at Scale*. https://nrc.canada.ca/en/research-development/research-collaboration/platform-decarbonize-construction-sector-scale

Change toolkit for digital building permit—CHEK. (2022). https://chekdbp.eu/

CIVITTA. (2018a). *Background document of developing the vision of e-construction platform* (p. 28). e-ehuitus. https://eehitus.ee/wp-content/uploads/2019/07/e-construction-platform-background-ENG.pdf

CIVITTA. (2018b). *Vision of e-construction platform* (p. 28). e-ehuitus. https://eehitus.ee/wp-content/uploads/2019/07/e-construction-platform-vision-ENG.pdf

DigiPLACE 2021 Booklet. (2021). https://digiplaceproject.eu/finalbooklet/

Digital Construction Ecosystem – IAAC BLOG. (2024). https://blog.iaac.net/digital-construction-ecosystem/

Dridi, A., Vakaj, E., Patlakas, P., Hettiarachchi, H., Beach, T., Yeung, J., Costa, G., Hradil, P., & Tan, H. (2023). *D2.2 BCO Ontology and Rules Format* (2.2; ACCORD - Automated Compliance Checks for Construction, Renovation or Demolition Works). European Union. https://accordproject.eu/wp-content/uploads/2024/02/ACCORD_D2.2_BCO_Ontology_and_Rules_Format.pdf

Government of Canada, P. S. and P. C. (2017, June 7). *Contract Security Manual – Security requirements for contracting with the Government of Canada—Security screening—National security—National Security and Defence – Canada.ca*. https://www.tpsgc-pwgsc.gc.ca/esc-src/msc-csm/index-eng.html

Heiler, S. (1995). Semantic interoperability. *ACM Comput. Surv.*, *27*(2), 271–273. https://doi.org/10.1145/210376.210392

ISO. (2015). *ISO 12006-2:2015 Building construction—Organization of information about construction works—Part 2: Framework for classification* [Protocol-Standard or Code]. https://www.iso.org/cms/render/live/en/sites/isoorg/contents/data/standard/06/17/61753.html

ISO 5127. (2017). *ISO 5127:2017—Information and documentation—Foundation and vocabulary*. https://www.iso.org/standard/59743.html

ISO 7817-1. (2024). *ISO 7817-1:2024*. ISO. https://www.iso.org/standard/82914.html

ISO 10303-2. (2024). *ISO 10303-2:2024—Industrial automation systems and integration—Product data representation and exchange—Part 2: Vocabulary*. https://www.iso.org/standard/81196.html

ISO 16739-1. (2024). *ISO 16739-1:2024*. ISO. https://www.iso.org/standard/84123.html

ISO 19101-1:2014—Geographic information—Reference model—Part 1: Fundamentals. (n.d.). Retrieved August 2, 2024, from https://www.iso.org/standard/59164.html

ISO 19109. (2015). *ISO 19109:2015*. ISO. https://www.iso.org/standard/59193.html

ISO 19763-9. (2015). *ISO/IEC TR 19763-9:2015*. ISO 19763. https://www.iso.org/standard/56080.html

ISO 22274. (2013). *ISO 22274:2013*. ISO. https://www.iso.org/standard/36173.html

ISO 25964-2. (2013). *ISO 25964-2:2013*. ISO. https://www.iso.org/standard/53658.html

ISO 28258. (2013). *ISO 28258:2013*. ISO. https://www.iso.org/standard/44595.html

ISO 29481-1. (2016). *ISO 29481-1:2016*. ISO. https://www.iso.org/standard/60553.html

ISO/IEC 15944-7. (2009). *ISO/IEC 15944-7:2009*. ISO. https://www.iso.org/standard/51545.html

ISO/IEC 18012-1. (2004). *ISO/IEC 18012-1:2004*. ISO. https://www.iso.org/standard/30797.html

ISO/TR 13054. (2012). *ISO/TR 13054:2012*. ISO. https://www.iso.org/standard/52465.html

Jaanisoo, I. (2021). *Long-Term View on Construction 2035*.

Leal, D., Cook, A., Partridge, C., Sullivan, J., & West, M. (2020). *A Survey of Industry Data Models and Reference Data Libraries—To identify requirements for, and provide input to, a Foundation Data Model*. CDBB. https://www.cdbb.cam.ac.uk/files/industry_data_models_and_reference_data_libraries_0.pdf

Mecharnia, T., Lefrançois, M., Zimmermann, A., Vakaj, E., Dridi, A., Hettiarachchi, H., Alexiev, V., Keberle, N., Tan, H., Noardo, F., Makkinga, R., & Cheung, F. (2023). *Existing ontologies, standards, and data models in the building data domain relevant to compliance checking* (D2.1 Technical Report: Existing Models; ACCORD - Automated Compliance Checks for Construction, Renovation or Demolition Works, p. 121). https://accordproject.eu/wp-content/uploads/2023/09/ACCORD_D2.1_Technical_Report_Existing_Models.pdf

Menzel, K., Törmä, S., Markku, K., Tsatsakis, K., Hryshchenko, A., & Lucky, M. N. (2022). Linked Data and Ontologies for Semantic Interoperability. In B. Daniotti, S. Lupica Spagnolo, A. Pavan, & C. M. Bolognesi (Eds.), *Innovative Tools and Methods Using BIM for an Efficient Renovation in Buildings* (pp. 17–28). Springer International Publishing. https://doi.org/10.1007/978-3-031-04670-4_2

Mirarchi, C., Naville, N., David, A., Pastorelly, N., & Zarli, A. (2021). *Toward a Reference Architecture Framework for the development of interoperable construction digital platforms in Europe*.

National Research Council Canada. (2019). *Canadian National Master Construction Specification (NMS) User Guide*. National Research Council Canada. https://nrc.canada.ca/sites/default/files/2019-10/NMS_Users_Guide_2019-08_en.pdf

Partridge, C., Mitchell, A., Cook, A., Sullivan, J., & West, M. (2020). *A Survey of Top-Level Ontologies—To inform the ontological choices for a Foundation Data Model*. CDBB. https://doi.org/10.17863/CAM.58311

Plateforme collaborative des pros de la construction. (n.d.). Retrieved August 1, 2024, from https://kroqi.fr/

Poirier, E. A., Forgues, D., & Staub-French, S. (2014). Dimensions of Interoperability in the AEC Industry. *Construction Research Congress 2014*, 1987–1996. https://doi.org/10.1061/9780784413517.203

Poirier, E. A., Staub-French, S., Whitell, M., Shahi, A., & Dadmehr, N. (2022). *Digital Transformation in the Canadian Built Asset Industry: Priorities for BIM Policy, Standardization, and Guidance*. Canadian Standards Association. https://www.csagroup.org/article/research/digital-transformation-in-the-canadian-built-asset-industry/

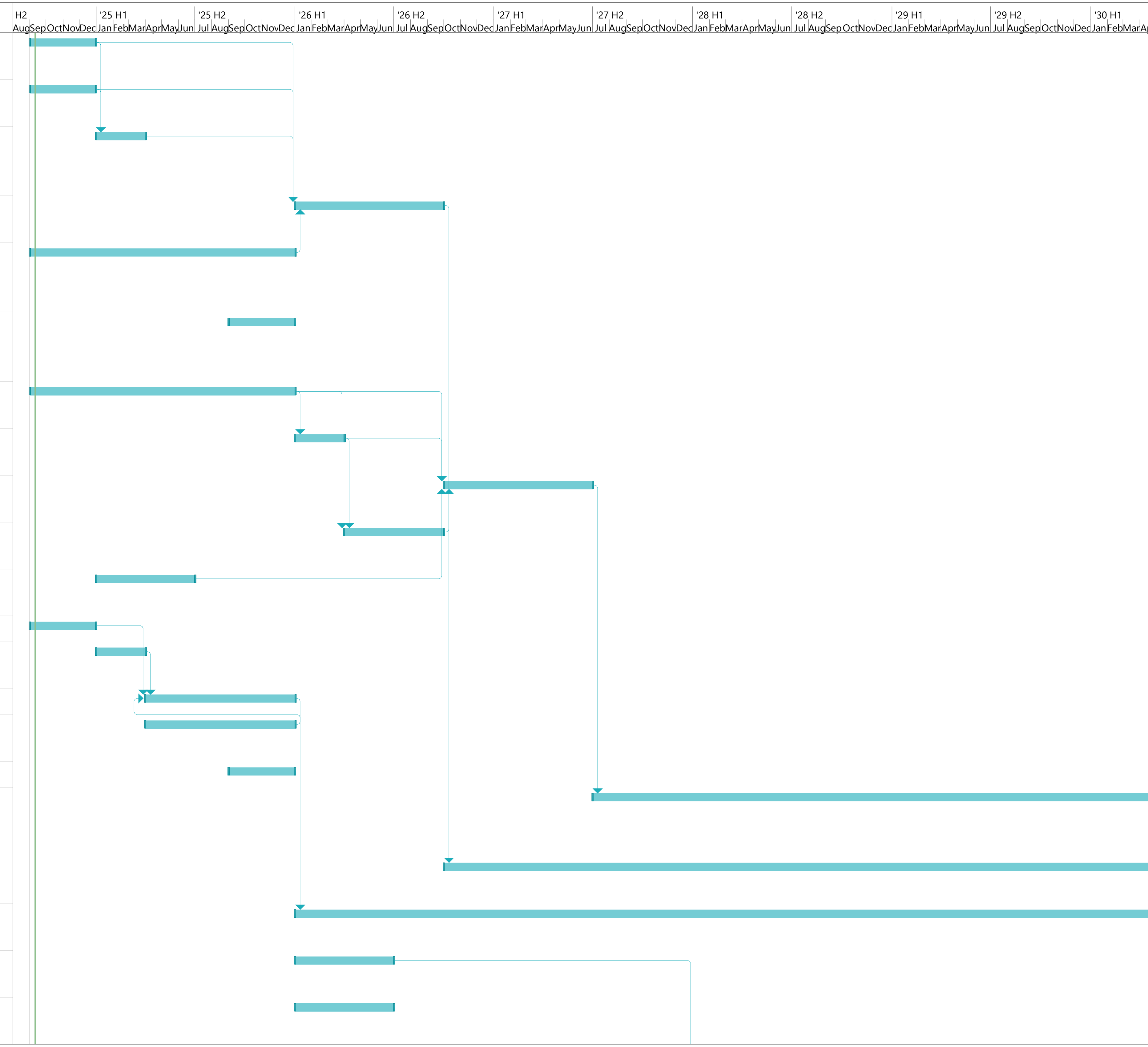
Rasmussen, M.H., Pauwels, P., Poveda-Villalón, M., Tiwari, S., García-Castro, R., Bourreau, P., Fies, B., Sschlenger, J., Daniotti, B., Törma, S., Thomas, M., Böhms, M., Sziebig, G., Font, A., Loscos, E., Vicente-Legazpi, P., & Imbrechts, P. (2022). *Ontologies and building digital twins*. SPHERE Digital Twin project. https://sphere-project.eu/download/ontologies-and-building-digital-twins/

The DigiPLACE project. (2019, 2021). https://www.digiplaceproject.eu/about

Appendix 1 -

NRC DCP R&D Roadmap

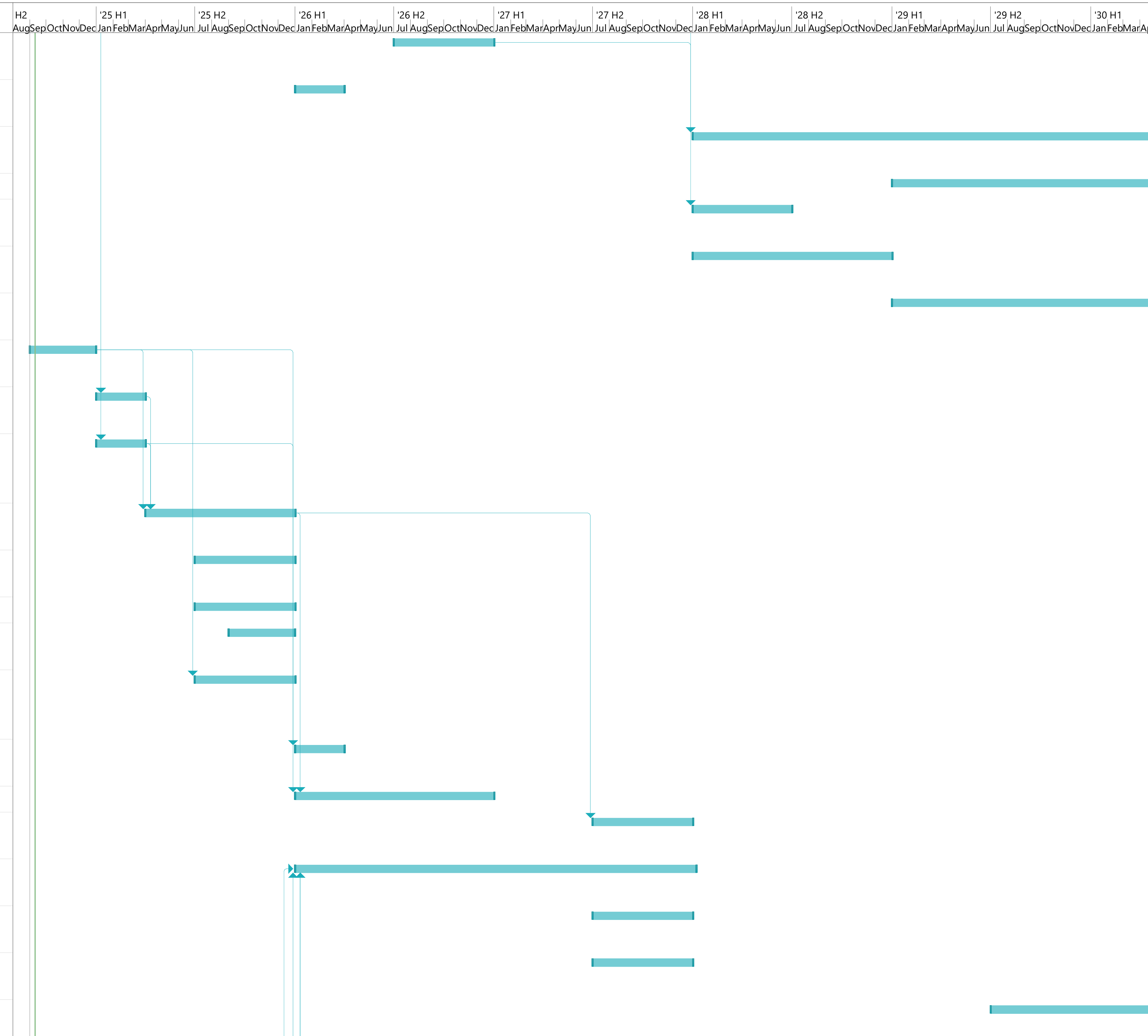
ID	Task Name	Duration	Start	Finish
1	1.1.01 Conduct a comprehensive audit of existing NRC content (NMCC, NMS, CCMC) to establish digitization strategy	88 days	Sun 24-09-01	Tue 24-12-31
2	1.1.02 Identify machine-readable format requirements for each resource type	88 days	Sun 24-09-01	Tue 24-12-31
3	1.1.03 Develop initial structure for NMCC content, including IM Specifications and Information Requirements, with consideration for supporting building permit application workflows	65 days	Wed 25-01-01	Tue 25-04-01
4	1.1.04 Begin digitization of NMCC content towards machine-readable formats	196 days	Thu 26-01-01	Thu 26-10-01
5	1.1.05 Establish standardized format for NMCC regulatory publications, including sharing NMCC regulatory publications with other government agencies	350 days	Sun 24-09-01	Thu 26-01-01
6	1.1.06 Initiate development of provincial and regional adaptations of the NMCC, incorporating digitization of relevant regulations, with a focus on land-use plans and zoning	88 days	Mon 25-09-01	Wed 25-12-31
7	1.1.07 Establish standardized format for NMS, as well as sharing NMS publications with other government agencies	350 days	Sun 24-09-01	Thu 26-01-01
8	1.1.08 Develop initial structure for NMS, including regulatory publications, specifications, and data templates	65 days	Thu 26-01-01	Wed 26-04-01
9	1.1.09 Begin digitization of NMS content towards machine-readable formats	196 days	Thu 26-10-01	Thu 27-07-01
10	1.1.10 Design and implement initial digital catalog for NMS, incorporating standardized specification templates	132 days	Wed 26-04-01	Thu 26-10-01
11	1.1.11 Establish ongoing content development process involving industry experts for NMS updates	130 days	Wed 25-01-01	Tue 25-07-01
12	1.1.12 Establish standardized format for CCMC related publications	88 days	Sun 24-09-01	Tue 24-12-31
13	1.1.13 Develop initial structure for CCMC material passports and product data templates	65 days	Wed 25-01-01	Tue 25-04-01
14	1.1.14 Begin digitization of CCMC content	198 days	Tue 25-04-01	Thu 26-01-01
15	1.1.15 Design digital product catalog for CCMC, incorporating standardized product data templates	198 days	Tue 25-04-01	Thu 26-01-01
16	1.1.16 Implement quality control measures for published content	88 days	Mon 25-09-01	Wed 25-12-31
17	1.1.17 Continue digitization of NMCC content, including all IM Specifications and Information Requirements as well as machine-readable rule sets	739 days	Thu 27-07-01	Tue 30-04-30
18	1.1.19 Continue digitization of NMS content, including all specifications and data templates	934 days	Thu 26-10-01	Tue 30-04-30
19	1.1.21 Continue development of CCMC digital product catalog with comprehensive product data	1129 days	Thu 26-01-01	Tue 30-04-30
20	1.1.22 Develop and implement content validation processes for all resource types	130 days	Thu 26-01-01	Wed 26-07-01
21	1.1.23 Develop standardized metadata schemas for each content type, leveraging existing ontologies	130 days	Thu 26-01-01	Wed 26-07-01



Project: DCP Roadmap-_MASTE
Date: Wed 24-09-11

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress	

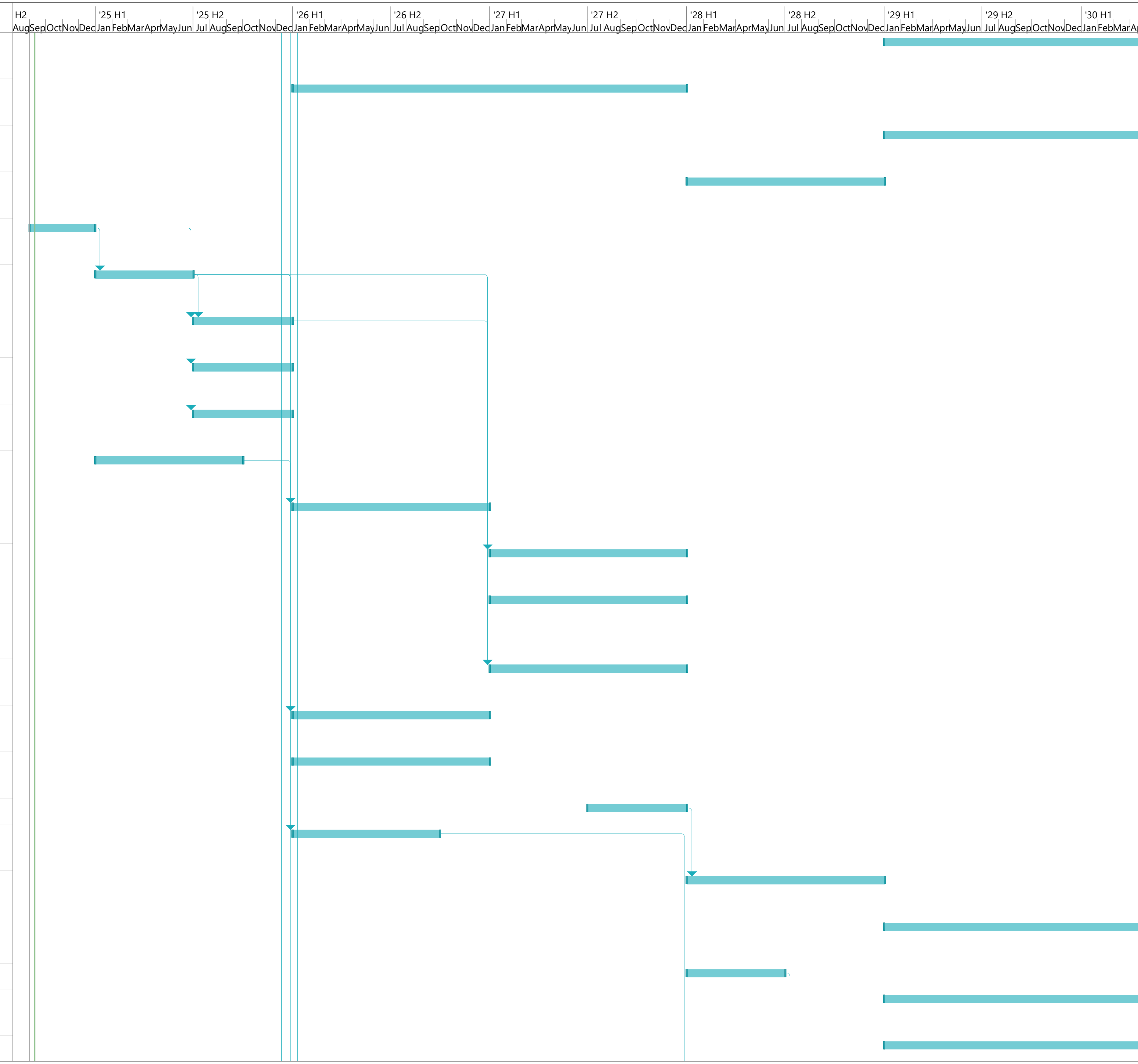
ID	Task Name	Duration	Start	Finish
22	1.1.24 Enable semantic linking across NMCC, NMS, and CCMC resources	133 days	Wed 26-07-01	Fri 27-01-01
23	1.1.25 Implement version control and change tracking for all digital content	65 days	Thu 26-01-01	Wed 26-04-01
24	1.1.27 Implement advanced content features (e.g., cross-referencing, semantic linking)	608 days	Sat 28-01-01	Tue 30-04-30
25	1.1.28 Develop AI-assisted content creation and updating tools	347 days	Mon 29-01-01	Tue 30-04-30
26	1.1.29 Implement advanced version control and change tracking for all digital content	132 days	Sat 28-01-01	Sat 28-07-01
27	1.1.30 Establish comprehensive digital content lifecycle management system	262 days	Sat 28-01-01	Mon 29-01-01
28	1.1.31 Implement automated workflows for pushing content to NRC DCP and linking to other content	347 days	Mon 29-01-01	Tue 30-04-30
29	1.2.01 Evaluate, select and/or confirm appropriate semantic resources within CDF (classifications, ontologies, etc.)	88 days	Sun 24-09-01	Tue 24-12-31
30	1.2.02 Assess syntactic resources (e.g., XML, JSON, IFC) for each content type	65 days	Wed 25-01-01	Tue 25-04-01
31	1.2.03 Review conceptual resources (e.g., IFC data model) for alignment with NRC needs, including BIM model requirements and validation rules	65 days	Wed 25-01-01	Tue 25-04-01
32	1.2.04 Identify gaps in existing resources and plan for custom development	198 days	Tue 25-04-01	Thu 26-01-01
33	1.2.05 Establish guidelines for using standard protocols (e.g., SOAP, REST) in API development	133 days	Tue 25-07-01	Thu 26-01-01
34	1.2.06 Develop integration strategy for CDF resources into NRC DCP	133 days	Tue 25-07-01	Thu 26-01-01
35	1.2.07 Begin development of resources and templates to support NMS content utilization	88 days	Mon 25-09-01	Wed 25-12-31
36	1.2.08 Begin adoption and customize relevant dictionaries (e.g., buildingSMART Data Dictionary) for key terms across NMCC, NMS, and CCMC	133 days	Tue 25-07-01	Thu 26-01-01
37	1.2.09 Implement selected semantic resources and undertake development of necessary ones	65 days	Thu 26-01-01	Wed 26-04-01
38	1.2.10 Integrate IFC data model for interoperability	262 days	Thu 26-01-01	Fri 27-01-01
39	1.2.11 Develop custom supporting resources for Canadian-specific needs	133 days	Thu 27-07-01	Sat 28-01-01
40	1.2.12 Develop and Implement Information Delivery Specifications (IDS) for Code Requirements	527 days	Thu 26-01-01	Fri 28-01-07
41	1.2.13 Implement semantic web technologies (e.g., RDF, OWL) for enhanced content relationships	133 days	Thu 27-07-01	Sat 28-01-01
42	1.2.14 Extend IM specifications to support automated zoning checks and local management by municipalities	133 days	Thu 27-07-01	Sat 28-01-01
43	1.2.16 Refine and expand supporting resources based on user feedback	218 days	Sun 29-07-01	Tue 30-04-30



Project: DCP Roadmap-_MASTE
Date: Wed 24-09-11

Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress	
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline		
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress		

ID	Task Name	Duration	Start	Finish
44	1.2.17 Adopt/Develop advanced ontologies for specific domains (e.g., energy efficiency, accessibility)	347 days	Mon 29-01-01	Tue 30-04-30
45	1.2.18 Design custom dictionaries for Canadian-specific terminologies	523 days	Thu 26-01-01	Sat 28-01-01
46	1.2.19 Implement advanced classification systems for emerging technologies	347 days	Mon 29-01-01	Tue 30-04-30
47	1.2.20 Develop tools for automatic classification and ontology mapping	262 days	Sat 28-01-01	Mon 29-01-01
48	1.3.01 Confirm current content development and curation workflows for NMCC, NMS, and CCMC	88 days	Sun 24-09-01	Tue 24-12-31
49	1.3.02 Design digital workflow diagrams for content development, curation, and distribution processes	130 days	Wed 25-01-01	Tue 25-07-01
50	1.3.03 Design initial digital workflow for CCMC product assessment and validation	133 days	Tue 25-07-01	Thu 26-01-01
51	1.3.04 Identify opportunities for process optimization and digitalization	133 days	Tue 25-07-01	Thu 26-01-01
52	1.3.05 Develop initial Information Delivery Manuals (IDMs) for key processes, following ISO 29481	133 days	Tue 25-07-01	Thu 26-01-01
53	1.3.06 Establish initial quality control measures for digital content and processes	196 days	Wed 25-01-01	Wed 25-10-01
54	1.3.07 Implement digital workflows for NMS content development, curation, and distribution	262 days	Thu 26-01-01	Fri 27-01-01
55	1.3.08 Develop automated processes for CCMC product assessment and validation	262 days	Fri 27-01-01	Sat 28-01-01
56	1.3.09 Develop workflow for integrating CCMC committee processes (Stakeholder, Scheme, Appeals, Impartiality) into NRC DCP	262 days	Fri 27-01-01	Sat 28-01-01
57	1.3.10 Develop workflow for integrating NMS committee processes into NRC DCP	262 days	Fri 27-01-01	Sat 28-01-01
58	1.3.11 Establish digital workflows for NMCC updates, including public review process	262 days	Thu 26-01-01	Fri 27-01-01
59	1.3.12 Integrate digital processes with NRC DCP, ensuring interoperability	262 days	Thu 26-01-01	Fri 27-01-01
60	1.3.13 Implement process monitoring and optimization tools	133 days	Thu 27-07-01	Sat 28-01-01
61	1.3.14 Develop and implement quality assurance processes for all digital content and services	196 days	Thu 26-01-01	Thu 26-10-01
62	1.3.15 Implement continuous improvement processes for digital workflows	262 days	Sat 28-01-01	Mon 29-01-01
63	1.3.16 Develop advanced automation for content updates and distribution	347 days	Mon 29-01-01	Tue 30-04-30
64	1.3.17 Initiate creation of AI-powered process optimization tools	132 days	Sat 28-01-01	Sat 28-07-01
65	1.3.18 Investigate blockchain for secure and transparent process tracking	347 days	Mon 29-01-01	Tue 30-04-30
66	1.3.19 Develop predictive analytics for process optimization	347 days	Mon 29-01-01	Tue 30-04-30



Project: DCP Roadmap-_MASTE
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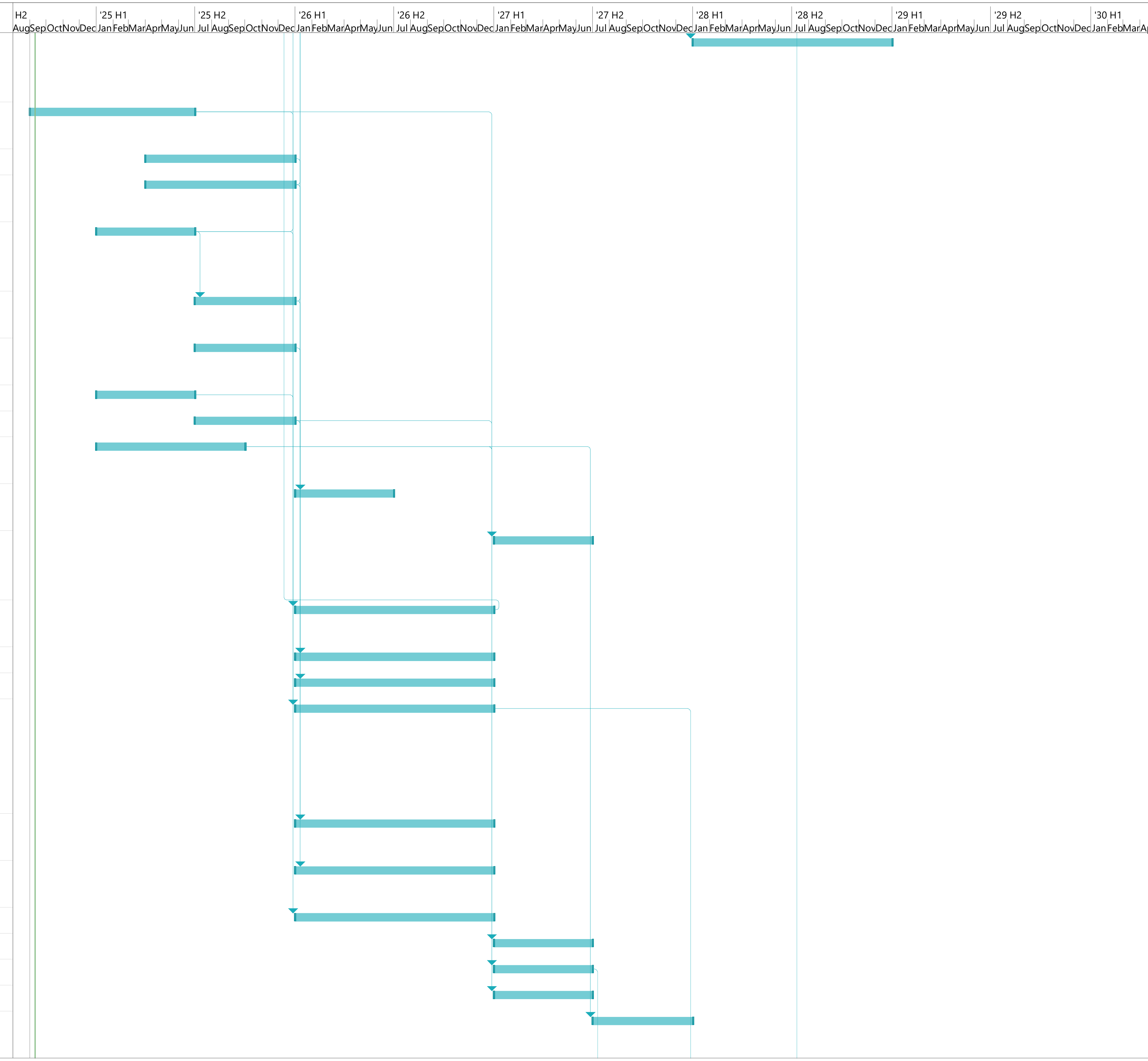
Task		Summary		Inactive Milestone		Duration-only		Start-only		External Milestone		Manual Progress	
Split		Project Summary		Inactive Summary		Manual Summary Rollup		Finish-only		Deadline			
Milestone		Inactive Task		Manual Task		Manual Summary		External Tasks		Progress			

ID	Task Name	Duration	Start	Finish
67	1.3.20 Implement advanced quality assurance and control mechanisms, including regular audits and automated validation checks	262 days	Sat 28-01-01	Mon 29-01-01
68	2.1.01 Confirm core platform requirements based on NMS, CCMC, and NMCC needs	218 days	Sun 24-09-01	Tue 25-07-01
69	2.1.02 Outline NMCC digital code management services	198 days	Tue 25-04-01	Thu 26-01-01
70	2.1.03 Design initial Rule Configuration Service for managing and updating rulesets	198 days	Tue 25-04-01	Thu 26-01-01
71	2.1.04 Plan basic Compliance Checking Services for Land Use, Building Permit, and Urban Regulations, including permit application processing	130 days	Wed 25-01-01	Tue 25-07-01
72	2.1.05 Design initial Information Requirements Service for permit applications and decision support, considering LOIN standards	133 days	Tue 25-07-01	Thu 26-01-01
73	2.1.06 Plan Zoning Requirements Service and Land Use Compliance Checking capabilities	133 days	Tue 25-07-01	Thu 26-01-01
74	2.1.07 Plan Digital Specification services for NMS	130 days	Wed 25-01-01	Tue 25-07-01
75	2.1.08 Outline CCMC product assessment and validation services	133 days	Tue 25-07-01	Thu 26-01-01
76	2.1.09 Design initial user interface for central access point to published content, services, and resources	196 days	Wed 25-01-01	Wed 25-10-01
77	2.1.10 Design initial manufacturer submission portal for material applications	130 days	Thu 26-01-01	Wed 26-07-01
78	2.1.11 Launch core DCP web portal (v1 alpha) with basic content access and search functions, including communication capabilities, and IFC file management for building applications	130 days	Fri 27-01-01	Thu 27-07-01
79	2.1.12 Deliver core DCP functions (e.g., content management, user authentication and authorization)	262 days	Thu 26-01-01	Fri 27-01-01
80	2.1.13 Implement NMCC digital code management services	262 days	Thu 26-01-01	Fri 27-01-01
81	2.1.14 Develop and implement Rule Configuration Service	262 days	Thu 26-01-01	Fri 27-01-01
82	2.1.15 Implement basic Compliance Checking Services with automated code checks, BIM viewer integration, support for both Geospatial and BIM (IFC) data inputs, building permit application processing, automated creation and viewing of building permit applic	262 days	Thu 26-01-01	Fri 27-01-01
83	2.1.16 Develop and implement Information Requirements Service and Building Permit Decision Support Service	262 days	Thu 26-01-01	Fri 27-01-01
84	2.1.17 Develop and implement Zoning Requirements Service and Land Use Compliance Checking Service	262 days	Thu 26-01-01	Fri 27-01-01
85	2.1.18 Build Digital Specification services for NMS	262 days	Thu 26-01-01	Fri 27-01-01
86	2.1.19 Develop CCMC product assessment and validation services	130 days	Fri 27-01-01	Thu 27-07-01
87	2.1.20 Develop basic analytics and reporting functionalities	130 days	Fri 27-01-01	Thu 27-07-01
88	2.1.21 Implement initial web services for third-party access	130 days	Fri 27-01-01	Thu 27-07-01
89	2.1.22 Implement feedback mechanism through the portal for continuous improvement	133 days	Thu 27-07-01	Sat 28-01-01



Project: DCP Roadmap-_MASTE
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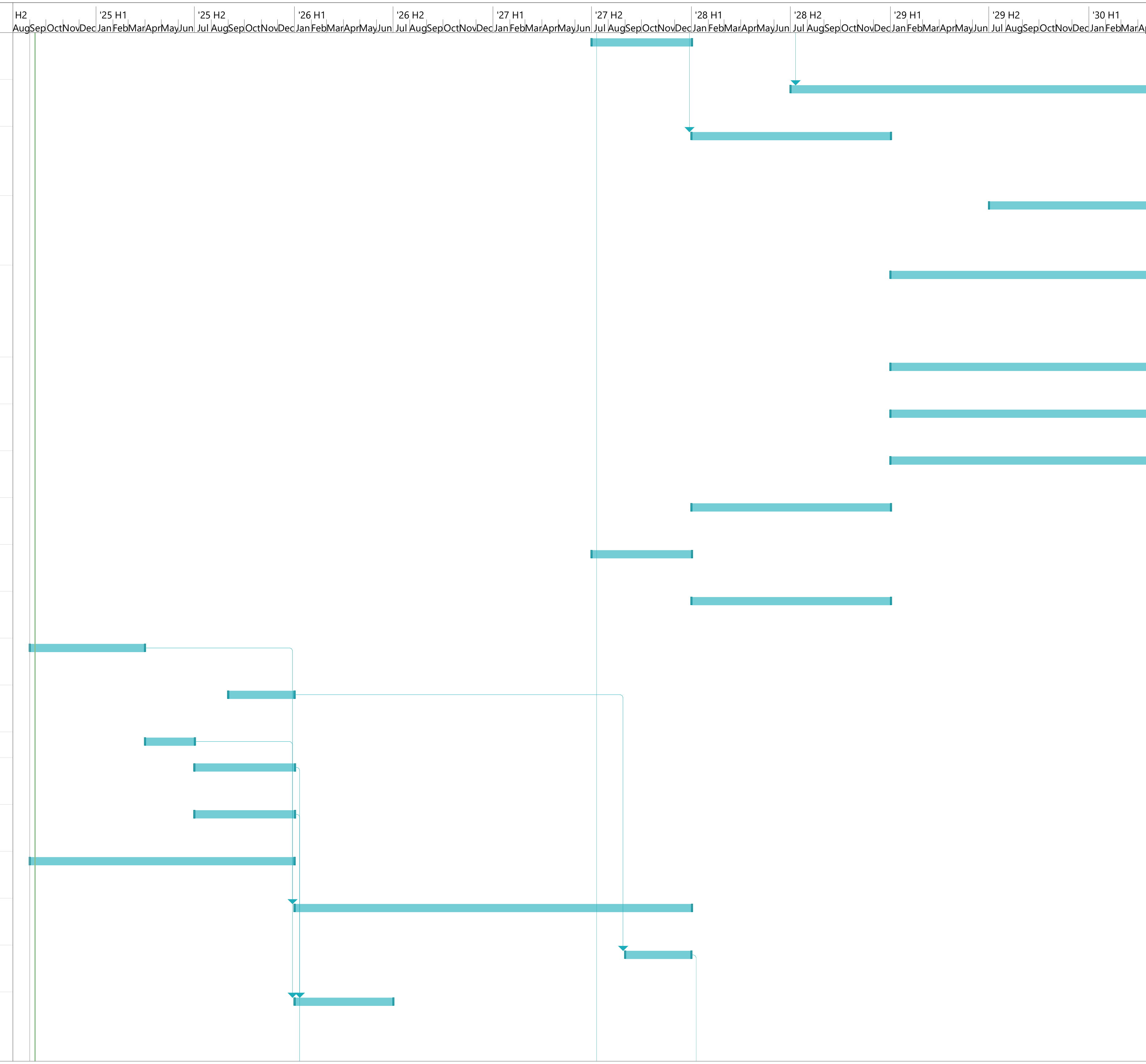
Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Progress | Manual Progress

ID	Task Name	Duration	Start	Finish
90	2.1.23 Implement manufacturer submission portal for material applications	133 days	Thu 27-07-01	Sat 28-01-01
91	2.1.24 Enhance Rule Configuration Service with AI-powered rule optimization	478 days	Sat 28-07-01	Tue 30-04-30
92	2.1.25 Implement advanced Compliance Checking Services with real-time updates, predictive analysis, and AI-assisted building permit processing	262 days	Sat 28-01-01	Mon 29-01-01
93	2.1.26 Deliver e-permitting processes integrated with provincial/municipal systems, including advanced decision support features	218 days	Sun 29-07-01	Tue 30-04-30
94	2.1.27 Develop and integrate advanced analytical tools (LCA, structural analysis, acoustic analysis, lighting analysis, energy analysis) with enhanced BIM-based compliance checking, analysis capabilities, and Green Building Compliance Checking	347 days	Mon 29-01-01	Tue 30-04-30
95	2.1.28 Investigate digital twin services for building lifecycle management	347 days	Mon 29-01-01	Tue 30-04-30
96	2.1.29 Implement AI-powered decision support tools for code interpretation and application	347 days	Mon 29-01-01	Tue 30-04-30
97	2.1.30 Develop virtual and augmented reality services for on-site code compliance checking and complex spatial regulations	347 days	Mon 29-01-01	Tue 30-04-30
98	2.1.31 Develop advanced simulation capabilities for testing regulatory scenarios	262 days	Sat 28-01-01	Mon 29-01-01
99	2.1.32 Implement automated zoning checks incorporating BIM and GIS technologies	133 days	Thu 27-07-01	Sat 28-01-01
100	2.1.33 Develop validation services for low-carbon construction materials, including basic Life Cycle Assessment (LCA) capabilities	262 days	Sat 28-01-01	Mon 29-01-01
101	2.2.01 Assess current systems, current data exchange methods. and integration points between NRC systems	152 days	Sun 24-09-01	Mon 25-03-31
102	2.2.02 Identify external systems for integration (e.g., provincial/municipal CDEs,, national cadastre, building registry)	88 days	Mon 25-09-01	Wed 25-12-31
103	2.2.03 Define API requirements for NRC DCP	66 days	Tue 25-04-01	Tue 25-07-01
104	2.2.04 Develop integration strategy with focus on openCDE principles	133 days	Tue 25-07-01	Thu 26-01-01
105	2.2.05 Create initial API specification document for core data exchange requirements	133 days	Tue 25-07-01	Thu 26-01-01
106	2.2.06 Plan for interconnected environments to enhance collaboration and data exchange	349 days	Sun 24-09-01	Wed 25-12-31
107	2.2.07 Support connections between NRC departments' Information Systems (NMS, CCMC, NMCC)	523 days	Thu 26-01-01	Sat 28-01-01
108	2.2.08 Implement integrations with key external systems (e.g., provincial code authorities/municipal CDEs)	88 days	Wed 27-09-01	Fri 27-12-31
109	2.2.09 Set data exchange protocols using standard formats (XML, JSON, IFC, CityGML) and implement support for Classification Systems (e.g., ISO 12006, Masterformat, Uniform).	130 days	Thu 26-01-01	Wed 26-07-01



Project: DCP Roadmap-_MASTE
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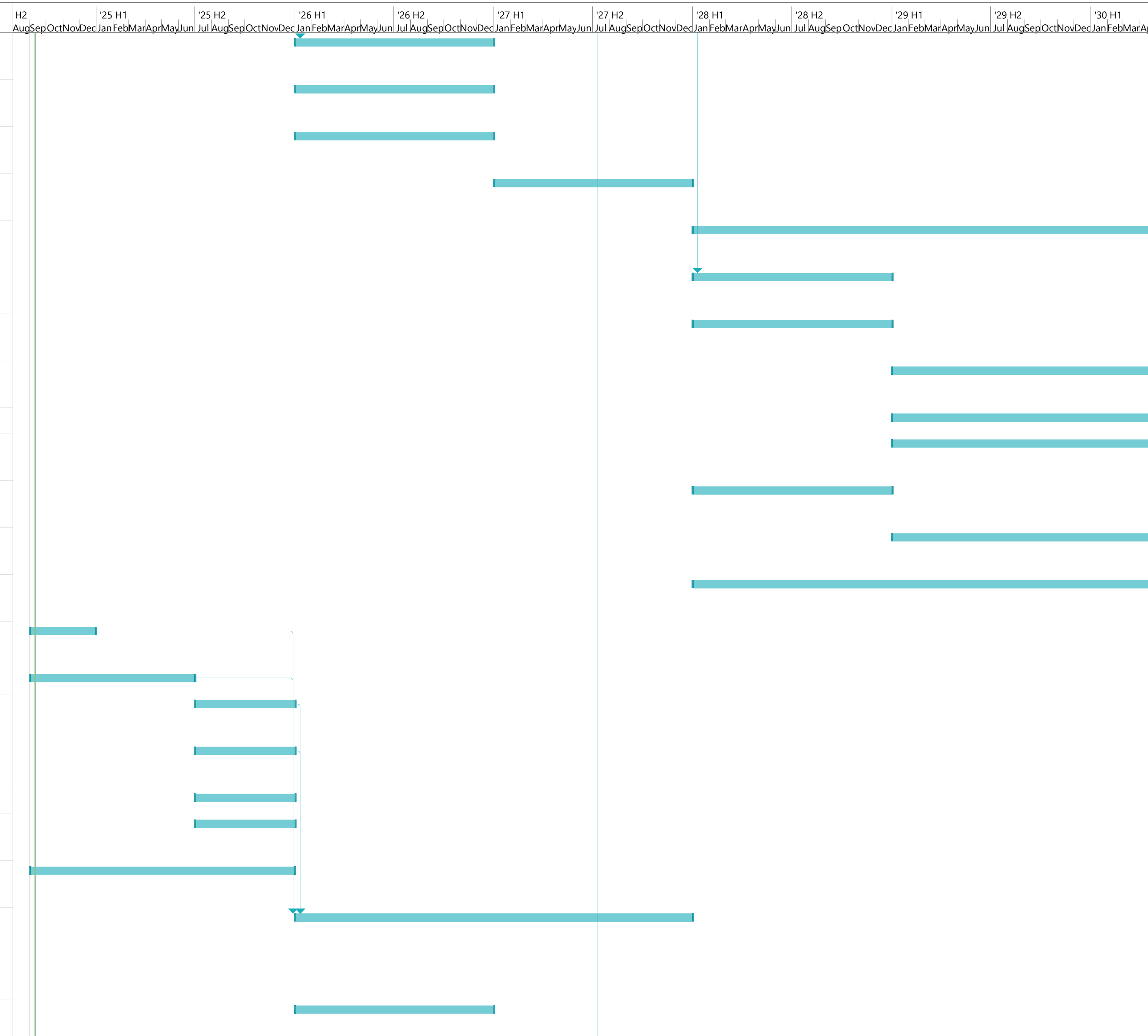
Task | Summary | Inactive Milestone | Duration-only | Start-only | External Milestone | Manual Progress
Split | Project Summary | Inactive Summary | Manual Summary Rollup | Finish-only | Deadline
Milestone | Inactive Task | Manual Task | Manual Summary | External Tasks | Progress

ID	Task Name	Duration	Start	Finish
110	2.2.10 Develop and test RESTful APIs for external access to DCP services	262 days	Thu 26-01-01	Fri 27-01-01
111	2.2.11 Implement security measures and access controls for all integrations	262 days	Thu 26-01-01	Fri 27-01-01
112	2.2.12 Implement initial BIM integration capabilities for NMS and CCMC content	262 days	Thu 26-01-01	Fri 27-01-01
113	2.2.13 Develop integrations for sharing regulatory publications between CCMC and other government agencies	262 days	Fri 27-01-01	Sat 28-01-01
114	2.2.14 Expand API ecosystem to support broader range of third-party applications	608 days	Sat 28-01-01	Tue 30-04-30
115	2.2.15 Implement advanced interoperability features with external platforms	262 days	Sat 28-01-01	Mon 29-01-01
116	2.2.16 Develop real-time data synchronization across all integrated systems	262 days	Sat 28-01-01	Mon 29-01-01
117	2.2.17 Investigate distributed ledger technology for secure data exchange and traceability	347 days	Mon 29-01-01	Tue 30-04-30
118	2.2.18 Create marketplace for third-party services and integrations	347 days	Mon 29-01-01	Tue 30-04-30
119	2.2.19 Support comprehensive Digital Twin capabilities, integrating real-time building data	347 days	Mon 29-01-01	Tue 30-04-30
120	2.2.20 Develop advanced BIM-based code compliance checking workflows	262 days	Sat 28-01-01	Mon 29-01-01
121	2.2.21 Extend integrations with smart city platforms, IoT systems, and advanced external databases	347 days	Mon 29-01-01	Tue 30-04-30
122	2.2.22 Ensure interoperability with external systems used for environmental impact assessments and zoning checks	608 days	Sat 28-01-01	Tue 30-04-30
123	2.3.01 Evaluate current data storage solutions for NMS, CCMC, and NMCC	88 days	Sun 24-09-01	Tue 24-12-31
124	2.3.02 Define requirements for centralized data repositories	218 days	Sun 24-09-01	Tue 25-07-01
125	2.3.03 Design initial repository structure for digital content within NRC DCP	133 days	Tue 25-07-01	Thu 26-01-01
126	2.3.04 Design initial database schemas for NMCC, NMS, and CCMC content	133 days	Tue 25-07-01	Thu 26-01-01
127	2.3.05 Deliver data migration plans for existing content	133 days	Tue 25-07-01	Thu 26-01-01
128	2.3.06 Implement version control system for digital content management and plan for archiving systems	133 days	Tue 25-07-01	Thu 26-01-01
129	2.3.07 Plan for centralized regulatory document and resource management	349 days	Sun 24-09-01	Wed 25-12-31
130	2.3.08 Fully implement centralized cloud-based data storage for NMS, CCMC, and NMCC content, including long-term archival storage for submitted models, integration with external databases, and cloud-based architecture for permitting services. Ensure integ	523 days	Thu 26-01-01	Sat 28-01-01
131	2.3.09 Develop advanced search and retrieval mechanisms for all content types	262 days	Thu 26-01-01	Fri 27-01-01



Project: DCP Roadmap-_MASTE
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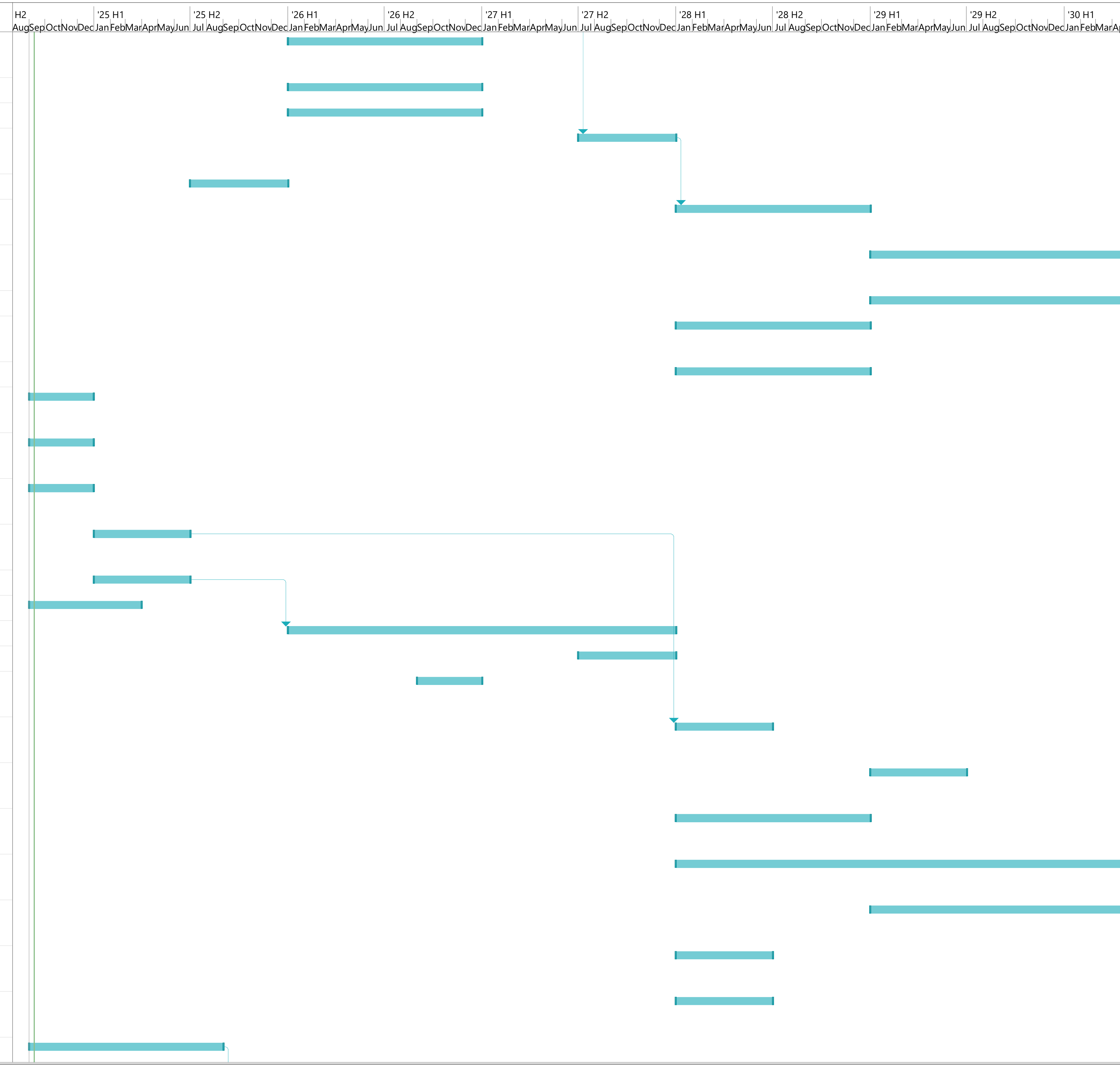
Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress	

ID	Task Name	Duration	Start	Finish
132	2.3.10 Implement data validation and integrity checks for all repositories	262 days	Thu 26-01-01	Fri 27-01-01
133	2.3.11 Create backup and disaster recovery systems for all DCP data	262 days	Thu 26-01-01	Fri 27-01-01
134	2.3.12 Establish data access controls and user permission systems	262 days	Thu 26-01-01	Fri 27-01-01
135	2.3.13 Develop initial data analytics capabilities for repository content	133 days	Thu 27-07-01	Sat 28-01-01
136	2.3.14 Develop structured information states for all content types	133 days	Tue 25-07-01	Thu 26-01-01
137	2.3.15 Implement advanced data analytics and reporting capabilities	262 days	Sat 28-01-01	Mon 29-01-01
138	2.3.16 Develop predictive maintenance and optimization features for repositories	347 days	Mon 29-01-01	Tue 30-04-30
139	2.3.17 Implement AI-powered data quality and consistency checks	347 days	Mon 29-01-01	Tue 30-04-30
140	2.3.18 Produce knowledge graph of all NRC DCP data for advanced querying	262 days	Sat 28-01-01	Mon 29-01-01
141	2.3.19 Develop data lake architecture for big data analytics	262 days	Sat 28-01-01	Mon 29-01-01
142	3.1.01 Establish project steering committee and working groups for ongoing project governance	88 days	Sun 24-09-01	Tue 24-12-31
143	3.1.02 Define governance structure including roles for NMS, CCMC, and NMCC stakeholders	88 days	Sun 24-09-01	Tue 24-12-31
144	3.1.03 Develop project charter and high-level project plan aligned with PDCSS objectives	88 days	Sun 24-09-01	Tue 24-12-31
145	3.1.04 Create risk management and mitigation strategies for identified project risks	130 days	Wed 25-01-01	Tue 25-07-01
146	3.1.06 Develop initial change management processes for the DCP	130 days	Wed 25-01-01	Tue 25-07-01
147	3.1.07 Implement project monitoring and reporting systems	152 days	Sun 24-09-01	Mon 25-03-31
148	3.1.08 Conduct change management processes for the DCP	523 days	Thu 26-01-01	Sat 28-01-01
149	3.1.09 Establish long-term governance model for DCP operations	133 days	Thu 27-07-01	Sat 28-01-01
150	3.1.10 Integrate CCMC committees (Stakeholder, Scheme, Appeals, Impartiality) into NRC DCP workflow	89 days	Tue 26-09-01	Fri 27-01-01
151	3.1.12 Implement advanced project portfolio management for ongoing DCP development	132 days	Sat 28-01-01	Sat 28-07-01
152	3.1.13 Transition from project-based to product-based management for ongoing DCP development	131 days	Mon 29-01-01	Sun 29-07-01
153	3.1.14 Implement advanced risk management and mitigation strategies for the operational platform	262 days	Sat 28-01-01	Mon 29-01-01
154	3.1.15 Develop international partnerships for knowledge exchange and potential platform expansion	608 days	Sat 28-01-01	Tue 30-04-30
155	3.1.16 Develop long-term strategic plan for DCP evolution and sustainability	347 days	Mon 29-01-01	Tue 30-04-30
156	3.1.17 Design governance model for third-party contributions and open-source components	132 days	Sat 28-01-01	Sat 28-07-01
157	3.1.18 Establish mechanism for ongoing evaluation and improvement of NRC DCP's tools and processes	132 days	Sat 28-01-01	Sat 28-07-01
158	3.2.01 Conduct skills assessment of NRC staff across departments	262 days	Sun 24-09-01	Mon 25-09-01



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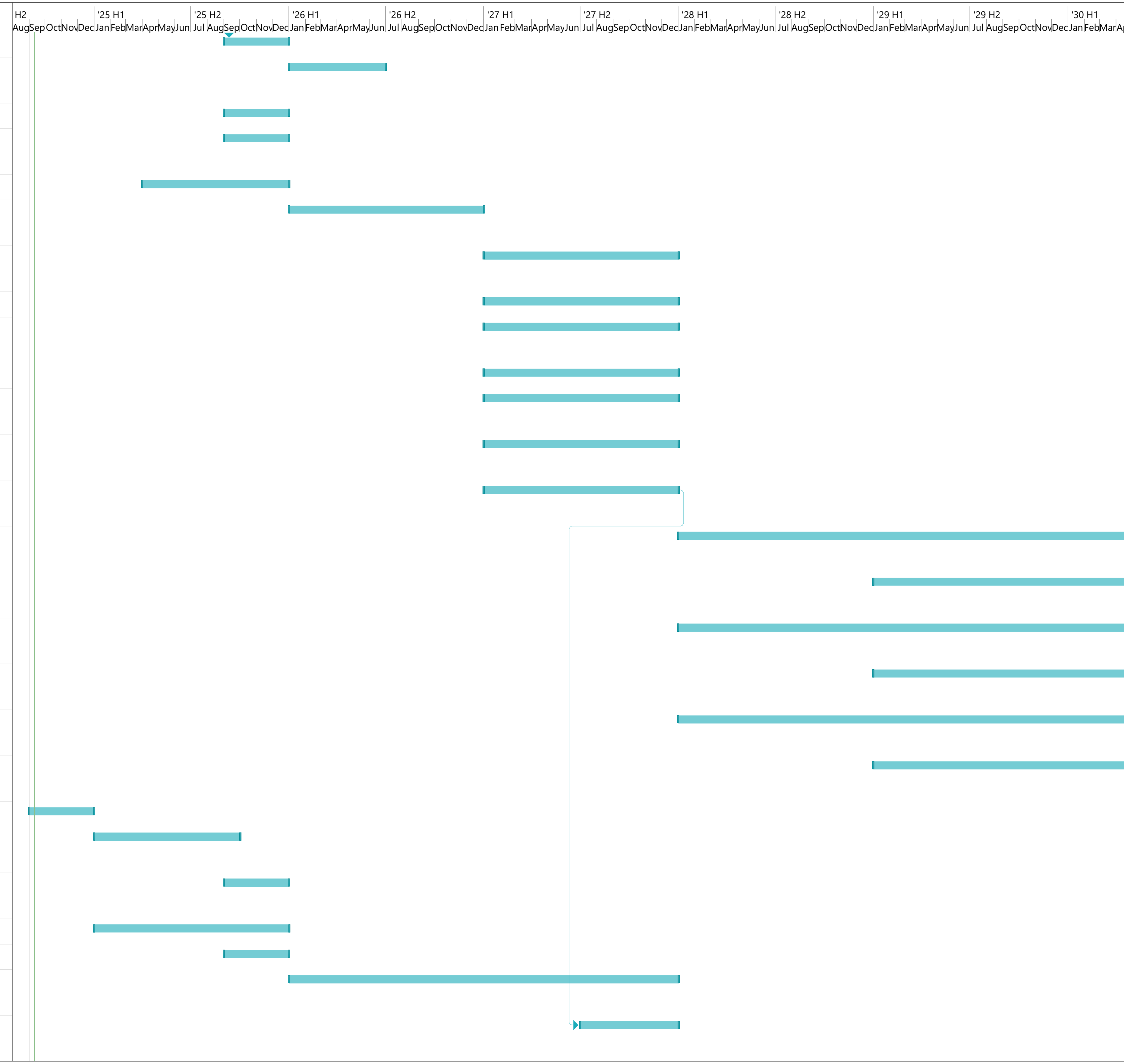
Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress	
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline		
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress		

ID	Task Name	Duration	Start	Finish
159	3.2.02 Identify skill gaps for DCP development and operation	88 days	Mon 25-09-01	Wed 25-12-31
160	3.2.03 Develop training plans for key technologies and methodologies (e.g., BIM, Data management/Linked Data)	130 days	Thu 26-01-01	Wed 26-07-01
161	3.2.04 Design capacity building strategy for NRC teams	88 days	Mon 25-09-01	Wed 25-12-31
162	3.2.05 Plan for ongoing education programs for external stakeholders	88 days	Mon 25-09-01	Wed 25-12-31
163	3.2.06 Begin creating user guides for early DCP components	198 days	Tue 25-04-01	Thu 26-01-01
164	3.2.07 Establish knowledge sharing mechanisms within the project team	262 days	Thu 26-01-01	Fri 27-01-01
165	3.2.08 Roll out training programs for NRC staff on new digital systems and processes	262 days	Fri 27-01-01	Sat 28-01-01
166	3.2.09 Develop user guides and documentation for NRC DCP	262 days	Fri 27-01-01	Sat 28-01-01
167	3.2.10 Develop e-learning modules for external stakeholders (e.g., industry professionals, regulators)	262 days	Fri 27-01-01	Sat 28-01-01
168	3.2.11 Establish help desk and support system for DCP users	262 days	Fri 27-01-01	Sat 28-01-01
169	3.2.12 Implement continuous learning program for evolving digital skills	262 days	Fri 27-01-01	Sat 28-01-01
170	3.2.13 Establish communities of practice around key DCP technologies	262 days	Fri 27-01-01	Sat 28-01-01
171	3.2.14 Develop training programs for effective utilization of analytical tools and automated checks	262 days	Fri 27-01-01	Sat 28-01-01
172	3.2.15 Implement advanced digital skills development program for NRC staff	608 days	Sat 28-01-01	Tue 30-04-30
173	3.2.16 Develop industry-wide certification programs for NRC DCP proficiency	347 days	Mon 29-01-01	Tue 30-04-30
174	3.2.17 Establish mentorship program for knowledge transfer within NRC	608 days	Sat 28-01-01	Tue 30-04-30
175	3.2.18 Establish center of excellence for digital construction practices	347 days	Mon 29-01-01	Tue 30-04-30
176	3.2.19 Develop collaborative research programs with academic institutions	608 days	Sat 28-01-01	Tue 30-04-30
177	3.2.20 Set-up innovation labs for ongoing research and development in digital construction	347 days	Mon 29-01-01	Tue 30-04-30
178	3.3.01 Develop comprehensive stakeholder engagement plan	88 days	Sun 24-09-01	Tue 24-12-31
179	3.3.02 Produce communication strategy for internal and external stakeholders	196 days	Wed 25-01-01	Wed 25-10-01
180	3.3.03 Design awareness campaign materials about NRC DCP initiative	88 days	Mon 25-09-01	Wed 25-12-31
181	3.3.04 Establish feedback mechanisms for continuous improvement	262 days	Wed 25-01-01	Thu 26-01-01
182	3.3.05 Plan and execute kick-off events for key stakeholder groups	88 days	Mon 25-09-01	Wed 25-12-31
183	3.3.06 Expand stakeholder engagement to include broader industry groups	523 days	Thu 26-01-01	Sat 28-01-01
184	3.3.07 Develop and distribute educational materials about the NRC DCP	133 days	Thu 27-07-01	Sat 28-01-01



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Task	Summary	Inactive Milestone	Duration-only	Start-only	External Milestone	Manual Progress
Split	Project Summary	Inactive Summary	Manual Summary Rollup	Finish-only	Deadline	
Milestone	Inactive Task	Manual Task	Manual Summary	External Tasks	Progress	

ID	Task Name	Duration	Start	Finish
185	3.3.08 Develop case studies and success stories from early DCP adoption	262 days	Fri 27-01-01	Sat 28-01-01
186	3.3.09 Plan and execute industry events to showcase DCP capabilities	262 days	Fri 27-01-01	Sat 28-01-01
187	3.3.10 Establish feedback loop for continuous improvement based on user input	262 days	Fri 27-01-01	Sat 28-01-01
188	3.3.11 Establish regular communication channels (newsletters, webinars) for updates	262 days	Fri 27-01-01	Sat 28-01-01
189	3.3.12 Plan and execute series of workshops for key stakeholder groups	262 days	Fri 27-01-01	Sat 28-01-01
190	3.3.13 Launch international knowledge-sharing initiatives	132 days	Sat 28-01-01	Sat 28-07-01
191	3.3.14 Develop case studies and best practices documentation	608 days	Sat 28-01-01	Tue 30-04-30
192	3.3.15 Develop comprehensive digital marketing strategy for global promotion of DCP	608 days	Sat 28-01-01	Tue 30-04-30
193	3.3.16 Design immersive demonstration environments for showcasing DCP capabilities	608 days	Sat 28-01-01	Tue 30-04-30
194	3.3.17 Implement advanced user feedback and co-creation platforms	347 days	Mon 29-01-01	Tue 30-04-30
195	3.3.18 Host international conferences on digital transformation in construction	608 days	Sat 28-01-01	Tue 30-04-30
196	3.3.19 Create online community platform for DCP users and developers	262 days	Sat 28-01-01	Mon 29-01-01
197	3.3.20 Establish regular industry-wide conferences and events	608 days	Sat 28-01-01	Tue 30-04-30
198	3.3.21 Develop comprehensive impact assessment and reporting system for NRC DCP	218 days	Sun 29-07-01	Tue 30-04-30
199		NaN		Wed 25-12-31
200		NaN		Thu 26-12-31
201		NaN		Fri 27-12-31
202		NaN		Sun 28-12-31
203		NaN		Mon 29-12-31
204		NaN		Tue 30-04-30

Project: DCP Roadmap-_MASTE
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Task | Summary | Inactive Milestone | Duration-only | Start-only | External Milestone | Manual Progress
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Milestone | Inactive Task | Manual Task | Manual Summary | External Tasks | Progress

1. Digital Resources

Activity ID: 1.1.01

1.1 Digital Content

Conduct a comprehensive audit of existing NRC content (NMCC, NMS, CCMC) to establish digitization strategy

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves a thorough review and analysis of all existing content across the National Model Construction Codes (NMCC), National Master Specifications (NMS), and Canadian Construction Materials Centre (CCMC). The audit will assess the current state of digitization, identify gaps, and determine priorities for the digitization process. Key tasks include cataloging all content types, evaluating their current format and structure, and assessing their suitability for machine-readable conversion.

Target / Deliverables

Audit report detailing the current state of NRC content, including a comprehensive inventory, digitization status, and recommendations for prioritization in the digitization strategy.

Responsible party

Activity type: Content cataloging and structuring

Scenario: General

CDF Resource: *delivery

Predecessor:

1. Digital Resources

Activity ID: 1.1.02

1.1 Digital Content

Identify machine-readable format requirements for each resource type

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity focuses on determining the most appropriate machine-readable formats for different types of content within NMCC, NMS, and CCMC. It involves researching industry standards, evaluating compatibility with existing systems, and considering future interoperability needs. Key tasks include consulting with technical experts, reviewing best practices in digital construction platforms, and aligning format choices with the broader goals of the NRC DCP.

Target / Deliverables

Detailed specification document outlining the chosen machine-readable formats for each content type, including rationale for selections and implementation guidelines.

Responsible party

Activity type: Resource cataloging and structuring

Scenario: General

CDF Resource: Syntax

Predecessor:

1. Digital Resources

Activity ID: 1.1.03

1.1 Digital Content

Develop initial structure for NMCC content, including IM Specifications and Information Requirements, with consideration for supporting building permit application workflows

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-04-01

Duration: 3 months

Decription

This activity involves creating a foundational structure for digitizing NMCC content. It includes developing Information Model (IM) Specifications and defining Information Requirements that align with building permit application processes. Key tasks include analyzing current NMCC structure, identifying key components for digitization, and designing a logical hierarchy that supports both human readability and machine processing.

Target / Deliverables

Initial NMCC digital content structure document, including IM Specifications and Information Requirements schema, aligned with building permit application workflows.

Responsible party

Activity type: Content cataloging and structuring

Scenario: NMCC

CDF Resource: Conceptual

Predecessor:

- 1.1.01

1. Digital Resources

Activity ID: 1.1.04

1.1 Digital Content

Begin digitization of NMCC content towards machine-readable formats

Phase 1 (2024-2025):

Start Date: 2026-01-01

End Date: 2026-10-01

Duration: 9 months

Decription

This activity initiates the conversion of NMCC content into the previously defined machine-readable formats. It involves setting up the necessary tools and processes for digitization, starting with priority content areas as identified in the audit. Key tasks include data entry or conversion, quality checks, and iterative refinement of the digitization process.

Target / Deliverables

First batch of digitized NMCC content in machine-readable format, along with a progress report detailing lessons learned and recommendations for ongoing digitization efforts.

Responsible party

Activity type: Content digitization

Scenario: NMCC

CDF Resource: *delivery

Predecessor:

- 1.1.01
- 1.1.02
- 1.1.03
- 1.1.05

1. Digital Resources

Activity ID: 1.1.05

1.1 Digital Content

Establish standardized format for NMCC regulatory publications, including sharing NMCC regulatory publications with other government agencies

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2026-01-01

Duration: 16 months

Decription

This activity focuses on creating a consistent, standardized digital format for NMCC regulatory publications and its sharing to ensure interoperability, uniformity and ease of digital processing, including across different levels of government. The process involves analyzing current publication formats, identifying essential elements, and designing a template that accommodates various types of regulatory content while maintaining machine-readability. Collaboration with regulatory experts and IT specialists will be crucial to balance compliance requirements with digital accessibility. It also involves consultations with federal, provincial, and municipal agencies to determine interoperability requirements. The format will be designed to facilitate seamless integration with various government information systems while maintaining the integrity and authority of the NMCC content.

Target / Deliverables

Standardized NMCC publication format template and style guide and standardized digital format specification for inter-governmental NMCC content sharing, including data exchange protocols, integration guidelines for digital formatting and metadata inclusion.

Responsible party

Activity type: Initial resource development

Scenario: NMCC

CDF Resource: Syntax

Predecessor:

1. Digital Resources

Activity ID: 1.1.06

1.1 Digital Content

Initiate development of provincial and regional adaptations of the NMCC, incorporating digitization of relevant regulations, with a focus on land-use plans and zoning

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity begins the process of adapting the NMCC for provincial and regional use within the digital framework. It encompasses identifying regional variations, digitizing local regulations, and integrating land-use plans and zoning information. The work involves close collaboration with provincial authorities and urban planners to ensure accurate representation of local requirements.

Target / Deliverables

Initial set of digitized provincial/regional NMCC adaptations, including digitized land-use plans and zoning regulations for select regions.

Responsible party

Activity type: Content development and validation

Scenario: NMCC

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.1.07

1.1 Digital Content

Establish standardized format for NMS, as well as sharing NMS publications with other government agencies

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2026-01-01

Duration: 16 months

Decription

Similar to the NMCC standardization, this activity aims to create a uniform format for NMS content. Furthermore, it involves creating a standardized digital format for sharing NMS publications with various government agencies. The format will be designed to support efficient updates and version control, ensuring that all agencies have access to the most current specifications. The process includes reviewing current NMS structures, identifying core components, and developing a standardized digital format that accommodates specifications, regulatory publications, and data templates. Engagement with industry and govenrment stakeholders will ensure the format meets practical needs while supporting digital functionality.

Target / Deliverables

Standardized digital format specification, including templates for regulatory publications, specifications, and data schemas.
Standardized digital format for inter-governmental NMS content sharing, including version control mechanisms and update protocols.

Responsible party

Activity type: Initial resource development

Scenario: NMS

CDF Resource: Syntax

Predecessor:

1. Digital Resources

Activity ID: 1.1.08

1.1 Digital Content

Develop initial structure for NMS, including regulatory publications, specifications, and data templates

Phase 1 (2024-2025):

Start Date: 2026-01-01

End Date: 2026-04-01

Duration: 3 months

Decription

Building on the standardized format, this activity involves creating the foundational digital structure for NMS content. The work includes organizing content categories, establishing hierarchies, and defining relationships between different NMS components. Consideration will be given to how this structure supports search, cross-referencing, and integration with other NRC DCP components.

Target / Deliverables

Initial NMS digital content structure document, detailing the organization of regulatory publications, specifications, and data templates within the digital framework.

Responsible party

Activity type: Content cataloging and structuring

Scenario: NMS

CDF Resource: Conceptual

Predecessor:

- 1.1.07

1. Digital Resources

Activity ID: 1.1.09

1.1 Digital Content

Begin digitization of NMS content towards machine-readable formats

Phase 1 (2024-2025):

Start Date: 2026-10-01

End Date: 2027-07-01

Duration: 9 months

Decription

This activity initiates the conversion of NMS content into machine-readable formats, following the structure and standards established in previous activities. The process involves systematic digitization of specifications, data templates, and regulatory publications. Attention will be given to maintaining the integrity of technical information while enhancing searchability and interoperability. The work will be carried out in phases, prioritizing high-impact sections of the NMS.

Target / Deliverables

First batch of digitized NMS content in machine-readable format, including a sample set of specifications and data templates, along with a digitization progress report.

Responsible party

Activity type: Content digitization

Scenario: NMS

CDF Resource: *delivery

Predecessor:

- 1.1.07
- 1.1.08
- 1.1.10
- 1.1.11

1. Digital Resources

Activity ID: 1.1.10

1.1 Digital Content

Design and implement initial digital catalog for NMS, incorporating standardized specification templates

Phase 1 (2024-2025):

Start Date: 2026-04-01

End Date: 2026-10-01

Duration: 6 months

Decription

This activity focuses on creating a digital catalog system for the NMS, integrating the newly digitized content. The catalog will incorporate standardized specification templates to ensure consistency across different sections. The design will consider user experience for both internal NRC staff and external stakeholders, implementing intuitive navigation and search functionalities.

Target / Deliverables

Functional prototype of the NMS digital catalog, featuring standardized specification templates and basic search capabilities.

Responsible party

Activity type: Content cataloging and structuring

Scenario: NMS

CDF Resource: Semantics

Predecessor:

- 1.1.07
- 1.1.08

1. Digital Resources

Activity ID: 1.1.11

1.1 Digital Content

Establish ongoing content development process involving industry experts for NMS updates

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-07-01

Duration: 6 months

Decription

This activity sets up a collaborative process for continuous NMS content development and updates. It involves creating workflows for industry expert engagement, content review cycles, and approval processes. The system will be designed to facilitate remote collaboration and version control, ensuring that the NMS remains current and reflective of industry best practices.

Target / Deliverables

Documented NMS content development process, including collaboration tools, review cycles, and update procedures, along with a list of engaged industry experts.

Responsible party

Activity type: Content development and validation

Scenario: NMS

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.1.12

1.1 Digital Content

Establish standardized format for CCMC related publications

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

Similar to the NMCC and NMS standardization efforts, this activity creates a uniform digital format for CCMC publications. The process involves analyzing current CCMC document structures, identifying key components, and developing a standardized format that supports both technical accuracy and digital accessibility. Special attention will be given to ensuring that product evaluation data is structured for easy integration with other NRC DCP components.

Target / Deliverables

Standardized CCMC digital publication format and guidelines, including templates for product evaluations and technical assessments.

Responsible party

Activity type: Initial resource development

Scenario: CCMC

CDF Resource: Syntax

Predecessor:

1. Digital Resources

Activity ID: 1.1.13

1.1 Digital Content

Develop initial structure for CCMC material passports and product data templates

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-04-01

Duration: 3 months

Decription

This activity focuses on creating a foundational digital structure for CCMC material passports and product data templates. It involves analyzing current CCMC evaluation processes, identifying key product attributes, and designing a standardized structure that supports both comprehensive product information and interoperability with other NRC DCP components. The structure will be developed with consideration for emerging trends in material traceability and life cycle assessment.

Target / Deliverables

Initial digital structure document for CCMC material passports and product data templates, including attribute schemas and interoperability specifications.

Responsible party

Activity type: Content cataloging and structuring

Scenario: CCMC

CDF Resource: Conceptual

Predecessor:

1. Digital Resources

Activity ID: 1.1.14

1.1 Digital Content

Begin digitization of CCMC content

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2026-01-01

Duration: 9 months

Decription

This activity initiates the conversion of existing CCMC content into the newly established digital formats. The process involves systematically digitizing product evaluations, technical assessments, and related documentation. Priority will be given to high-demand product categories and those with the most significant impact on building performance and safety. The digitization process will include rigorous quality control measures to ensure the accuracy of technical information.

Target / Deliverables

First set of digitized CCMC content, including a sample of material passports and product evaluations in the new digital format, along with a digitization progress report.

Responsible party

Activity type: Content digitization

Scenario: CCMC

CDF Resource: *delivery

Predecessor:

- 1.1.12
- 1.1.13
- 1.1.15

1. Digital Resources

Activity ID: 1.1.15

1.1 Digital Content

Design digital product catalog for CCMC, incorporating standardized product data templates

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2026-01-01

Duration: 9 months

Decription

This activity involves creating a comprehensive digital catalog system for CCMC products. The catalog will integrate the newly digitized content and incorporate standardized product data templates. The design will focus on user-friendly interfaces for both manufacturers submitting product information and end-users accessing evaluation data. Advanced search and filtering capabilities will be implemented to enhance the usability of the catalog.

Target / Deliverables

Functional prototype of the CCMC digital product catalog, featuring standardized data templates and advanced search functionalities.

Responsible party

Activity type: Content cataloging and structuring

Scenario: CCMC

CDF Resource: Conceptual

Predecessor:

1. Digital Resources

Activity ID: 1.1.16

1.1 Digital Content

Implement quality control measures for published content

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity establishes robust quality control processes for all digitized and published content across NMCC, NMS, and CCMC. It involves developing verification protocols, implementing automated consistency checks, and establishing review workflows. The quality control system will ensure the accuracy, completeness, and consistency of all digital content before it is made available through the NRC DCP.

Target / Deliverables

Comprehensive quality control framework document, including automated check scripts, review processes, and error resolution procedures.

Responsible party

Activity type: Content development and validation

Scenario: General

CDF Resource: *delivery

Predecessor:

1. Digital Resources

Activity ID: 1.1.17

1.1 Digital Content

Continue digitization of NMCC content, including all IM Specifications and Information Requirements as well as machine-readable rule sets

Phase 2 (2026-2027)

Start Date: 2027-07-01

End Date: 2030-04-30

Duration: 33 months

Decription

This activity represents the ongoing effort to digitize the full breadth of NMCC content. It expands upon the initial digitization work, focusing on converting all Information Model (IM) Specifications and Information Requirements into machine-readable formats. Additionally, it involves the development of machine-readable rule sets to support automated compliance checking. This process will require close collaboration between code experts and digital specialists to ensure accurate translation of code requirements into computable formats.

Target / Deliverables

Comprehensive set of digitized NMCC content, including machine-readable IM Specifications, Information Requirements, and rule sets, along with a detailed documentation of the digitization methodology.

Responsible party

Activity type: Content digitization

Scenario: NMCC

CDF Resource: *delivery

Predecessor:

- 1.1.09

1. Digital Resources

Activity ID: 1.1.19

1.1 Digital Content

Continue digitization of NMS content, including all specifications and data templates

Phase 2 (2026-2027)

Start Date: 2026-10-01

End Date: 2030-04-30

Duration: 42 months

Decription

Similar to the NMCC digitization, this activity represents the ongoing effort to digitize the entire NMS content library. It involves converting all specifications and data templates into the established machine-readable formats. The process will include updating and refining digitization methodologies based on lessons learned from earlier phases, ensuring consistency and quality across all digitized content.

Target / Deliverables

Full set of digitized NMS content, including all specifications and data templates in machine-readable formats, accompanied by a comprehensive digitization report.

Responsible party

Activity type: Content digitization

Scenario: NMS

CDF Resource: *delivery

Predecessor:

- 1.1.04

1. Digital Resources

Activity ID: 1.1.21

1.1 Digital Content

Continue development of CCMC digital product catalog with comprehensive product data

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2030-04-30

Duration: 51 months

Decription

This activity involves the ongoing enhancement and population of the CCMC digital product catalog. It includes digitizing and integrating a wide range of product data, expanding beyond basic specifications to include performance data, compliance information, and lifecycle assessments. The process will involve collaboration with manufacturers to ensure accurate and comprehensive product representation.

Target / Deliverables

Expanded CCMC digital product catalog with comprehensive product data, including performance metrics, compliance status, and lifecycle information.

Responsible party

Activity type: Content digitization

Scenario: CCMC

CDF Resource: *delivery

Predecessor:

- 1.1.14

1. Digital Resources

Activity ID: 1.1.22

1.1 Digital Content

Develop and implement content validation processes for all resource types

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2026-07-01

Duration: 6 months

Decription

This activity focuses on creating robust validation processes for all digitized content across NMCC, NMS, and CCMC. It involves developing automated validation scripts, establishing peer review protocols, and implementing version control systems. The validation processes will ensure data integrity, consistency, and accuracy across all digital resources.

Target / Deliverables

Comprehensive content validation framework, including automated validation tools, review protocols, and version control procedures.

Responsible party

Activity type: Content development and validation

Scenario: General

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.1.23

1.1 Digital Content

Develop standardized metadata schemas for each content type, leveraging existing ontologies

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2026-07-01

Duration: 6 months

Decription

This activity involves creating detailed metadata schemas for NMCC, NMS, and CCMC content. It will leverage existing construction industry ontologies and extend them where necessary to capture the specific needs of the NRC DCP. The schemas will facilitate advanced search capabilities, cross-referencing between resources, and integration with external systems.

Target / Deliverables

Standardized metadata schemas for each content type, with documentation on their alignment with industry ontologies and implementation guidelines.

Responsible party

Activity type: Initial resource development

Scenario: General

CDF Resource: Conceptual

Predecessor:

1. Digital Resources

Activity ID: 1.1.24

1.1 Digital Content

Enable semantic linking across NMCC, NMS, and CCMC resources

Phase 2 (2026-2027)

Start Date: 2026-07-01

End Date: 2027-01-01

Duration: 6 months

Decription

This activity focuses on implementing semantic linking capabilities across all NRC DCP resources. It involves identifying relationships between different content types, developing linking mechanisms, and creating a navigation structure that allows users to seamlessly move between related content in NMCC, NMS, and CCMC. This will enhance the overall usability and value of the platform.

Target / Deliverables

Semantic linking system with a user interface demonstrating cross-resource navigation and relationship mapping.

Responsible party

Activity type: Initial resource development

Scenario: General

CDF Resource: Semantics

Predecessor:

1. Digital Resources

Activity ID: 1.1.25

1.1 Digital Content

Implement version control and change tracking for all digital content

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2026-04-01

Duration: 3 months

Decription

This activity involves setting up a comprehensive version control and change tracking system for all digitized content. It includes implementing tools to track revisions, manage different versions of documents, and provide clear audit trails of changes. This system will be crucial for maintaining the integrity and traceability of official documents.

Target / Deliverables

Version control and change tracking system, complete with user guidelines and administrative protocols.

Responsible party

Activity type: Content development and validation

Scenario: General

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.1.27

1.1 Digital Content

Implement advanced content features (e.g., cross-referencing, semantic linking)

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

Building on the semantic linking established earlier, this activity involves implementing more advanced content features. This includes sophisticated cross-referencing capabilities, dynamic content updates based on regulatory changes, and intelligent content recommendations. These features will enhance the usability and value of the NRC DCP for all stakeholders.

Target / Deliverables

Suite of advanced content features integrated into the NRC DCP, with user documentation and performance metrics.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

- 1.1.24

1. Digital Resources

Activity ID: 1.1.28

1.1 Digital Content

Develop AI-assisted content creation and updating tools

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on leveraging artificial intelligence to assist in content creation and updates. It involves developing AI models trained on existing content to suggest updates, identify inconsistencies, and even draft new content for review. This will streamline the content management process and help maintain the currency of all resources.

Target / Deliverables

AI-assisted content management tools, including model documentation, user interfaces, and performance evaluation reports.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.1.29

1.1 Digital Content

Implement advanced version control and change tracking for all digital content

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2028-07-01

Duration: 6 months

Decription

This activity builds upon the basic version control system, implementing more sophisticated features. It includes developing branching and merging capabilities for parallel content development, implementing automated conflict resolution, and creating visual diff tools for easy comparison of document versions. The system will support the complex collaborative processes involved in developing and maintaining construction standards.

Target / Deliverables

Advanced version control system with branching, merging, and visual comparison tools, along with user and administrator guides.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

- 1.1.22

1. Digital Resources

Activity ID: 1.1.30

1.1 Digital Content

Establish comprehensive digital content lifecycle management system

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves creating a holistic system for managing the entire lifecycle of digital content, from creation through multiple revisions to archival. It includes defining content states (e.g., draft, review, approved, deprecated), establishing workflows for moving content between states, and implementing archival processes that maintain historical records while ensuring users always access the most current information.

Target / Deliverables

Comprehensive content lifecycle management system, including workflow documentation, state transition protocols, and archival procedures.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.1.31

1.1 Digital Content

Implement automated workflows for pushing content to NRC DCP and linking to other content

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on automating the process of publishing content to the NRC DCP and creating links between related pieces of content. It involves developing scripts to validate content readiness, automate the publication process, and generate appropriate metadata and links. This will streamline the content update process and ensure consistency across the platform.

Target / Deliverables

Automated content publication and linking system, with process documentation and performance metrics.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.2.01

1.2 Supporting Resourc

Evaluate, select and/or confirm appropriate semantic resources within CDF (classifications, ontologies, etc.)

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves a comprehensive review of existing semantic resources relevant to the construction domain. It includes evaluating various classification systems, ontologies, and terminologies to determine which are most appropriate for the NRC DCP. The selection will consider factors such as comprehensiveness, industry adoption, and alignment with Canadian practices.

Target / Deliverables

Report detailing selected semantic resources, including rationale for choices and implementation recommendations.

Responsible party

Activity type: Content cataloging and structuring

Scenario: General

CDF Resource: Semantics

Predecessor:

1. Digital Resources

Activity ID: 1.2.02

1.2 Supporting Resourc

Assess syntactic resources (e.g., XML, JSON, IFC) for each content type

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-04-01

Duration: 3 months

Decription

This activity focuses on evaluating different syntactic resources to determine the most appropriate for each type of content within the NRC DCP. It involves analyzing the strengths and limitations of various data formats, considering factors such as interoperability, processing efficiency, and industry adoption. The assessment will inform the choice of formats for different types of content and data exchange scenarios.

Target / Deliverables

Assessment report of syntactic resources, including recommendations for format usage across different content types and exchange scenarios.

Responsible party

Activity type: Resource cataloging and structuring

Scenario: General

CDF Resource: Syntax

Predecessor:

- 1.1.01
- 1.1.02

1. Digital Resources

Activity ID: 1.2.03

1.2 Supporting Resourc

Review conceptual resources (e.g., IFC data model) for alignment with NRC needs, including BIM model requirements and validation rules

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-04-01

Duration: 3 months

Decription

This activity involves a detailed review of conceptual resources, with a particular focus on their alignment with NRC's specific needs. It includes analyzing how well resources like the IFC data model support Canadian construction practices, assessing their ability to represent NRC-specific concepts, and evaluating their suitability for implementing validation rules. The review will inform any necessary extensions or adaptations of these resources.

Target / Deliverables

Conceptual resources alignment report, including gap analysis and recommendations for adaptations or extensions.

Responsible party

Activity type: Resource cataloging and structuring

Scenario: General

CDF Resource: Conceptual

Predecessor:

- 1.1.01
- 1.1.02

1. Digital Resources

Activity ID: 1.2.04

1.2 Supporting Resourc

Identify gaps in existing resources and plan for custom development

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2026-01-01

Duration: 9 months

Decription

Building on the evaluations of semantic, syntactic, and conceptual resources, this activity focuses on identifying any gaps that may hinder the full realization of the NRC DCP vision. It involves mapping the requirements of the platform against the capabilities of existing resources, identifying areas where custom development is needed, and creating a plan to address these gaps. This may include extending existing resources or developing entirely new ones.

Target / Deliverables

Gap analysis report and custom development plan, including prioritized list of development needs and high-level resource estimates.

Responsible party

Activity type: Resource cataloging and structuring

Scenario: General

CDF Resource: Semantics

Predecessor:

- 1.2.01
- 1.2.02
- 1.2.03

1. Digital Resources

Activity ID: 1.2.05

1.2 Supporting Resourc

Establish guidelines for using standard protocols (e.g., SOAP, REST) in API development

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves developing comprehensive guidelines for API development within the NRC DCP ecosystem. It includes evaluating different API protocols, determining best practices for their implementation, and creating standardized approaches for API design, documentation, and versioning. The guidelines will ensure consistency across all APIs developed for the platform, facilitating easier integration and maintenance.

Target / Deliverables

API development guidelines document, including protocol selection criteria, design standards, and documentation templates.

Responsible party

Activity type: Initial resource development

Scenario: General

CDF Resource: Practice

Predecessor:

1. Digital Resources

Activity ID: 1.2.06

1.2 Supporting Resourc

Develop integration strategy for CDF resources into NRC DCP

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on creating a strategy for integrating the Common Data Framework (CDF) resources into the broader NRC DCP. It involves mapping out how different CDF components (e.g., ontologies, data models) will be utilized across various platform functionalities, identifying integration points, and planning for any necessary adaptations. The strategy will ensure a cohesive and efficient use of CDF resources throughout the platform.

Target / Deliverables

CDF integration strategy, including resource utilization map, integration roadmap, and risk mitigation plan.

Responsible party

Activity type: Resource cataloging and structuring

Scenario: General

CDF Resource: *delivery

Predecessor:

1. Digital Resources

Activity ID: 1.2.07

1.2 Supporting Resourc

Begin development of resources and templates to support NMS content utilization

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity initiates the creation of supporting resources for NMS content within the digital platform. It involves developing templates for different types of specifications, creating guidance documents for content creation and usage, and designing tools to facilitate the application of NMS content in construction projects. These resources will enhance the usability and value of the digitized NMS.

Target / Deliverables

Initial set of NMS support resources, including specification templates, usage guidelines, and prototype utilization tools.

Responsible party

Activity type: Initial resource development

Scenario: NMS

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.2.08

1.2 Supporting Resourc

Begin adoption and customize relevant dictionaries (e.g., buildingSMART Data Dictionary) for key terms across NMCC, NMS, and CCMC

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on adopting and customizing industry-standard dictionaries to create a unified terminology across NMCC, NMS, and CCMC resources. It involves selecting appropriate base dictionaries, mapping existing terms to these standards, and extending the dictionaries where necessary to capture NRC-specific concepts. This will enhance interoperability and reduce ambiguity in the platform's content.

Target / Deliverables

Customized data dictionary for NRC DCP, including term mappings, extensions, and usage guidelines.

Responsible party

Activity type: Resource adoption and adaptation

Scenario: General

CDF Resource: Service

Predecessor:

- 1.2.01

1. Digital Resources

Activity ID: 1.2.09

1.2 Supporting Resourc

Implement selected semantic resources and undertake development of necessary ones

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2026-04-01

Duration: 3 months

Decription

Building on the earlier evaluation of semantic resources, this activity involves the actual implementation of selected resources and the development of any additional ones identified as necessary. It includes configuring existing ontologies and classification systems for use in the NRC DCP, as well as developing new semantic structures where gaps were identified. This will provide the semantic foundation for the platform's functionality.

Target / Deliverables

Implemented semantic resource suite, including configuration documentation, newly developed resources, and integration guidelines.

Responsible party

Activity type: Initial resource development

Scenario: General

CDF Resource: Semantics

Predecessor:

- 1.2.01

1. Digital Resources

Activity ID: 1.2.10

1.2 Supporting Resourc

Integrate IFC data model for interoperability

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on integrating the Industry Foundation Classes (IFC) data model into the NRC DCP to enhance interoperability with BIM systems. It involves mapping NRC-specific concepts to IFC entities, extending the IFC model where necessary, and developing tools to facilitate IFC data exchange within the platform. This integration will support seamless information flow between the NRC DCP and various BIM software used in the industry.

Target / Deliverables

Integrated IFC data model, including NRC-specific extensions, mapping documentation, and data exchange tools.

Responsible party

Activity type: Resource adoption and adaptation

Scenario: General

CDF Resource: Conceptual

Predecessor:
- 1.2.03
- 1.2.04

1. Digital Resources

Activity ID: 1.2.11

1.2 Supporting Resourc

Develop custom supporting resources for Canadian-specific needs

Phase 2 (2026-2027)

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity involves creating specialized resources to address unique Canadian construction requirements not adequately covered by existing international standards. It includes developing Canadian-specific classification systems, extending ontologies to incorporate local regulatory concepts, and creating specialized data schemas for provincial variations. This work ensures the NRC DCP accurately represents the Canadian construction landscape.

Target / Deliverables

Suite of Canadian-specific digital resources, including extended ontologies, classification systems, and data schemas, with implementation guidelines.

Responsible party

Activity type: Initial resource development

Scenario: General

CDF Resource: Semantics

Predecessor:

- 1.2.04

1. Digital Resources

Activity ID: 1.2.12

1.2 Supporting Resourc

Develop and Implement Information Delivery Specifications (IDS) for Code Requirements

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2028-01-07

Duration: 24 months

Decription

This activity involves both the creation and implementation of Information Delivery Specifications for code requirements within the NRC DCP. It begins with developing IDS aligned with international standards like ISO 29481 and ISO 7817, defining the specific information needed at various stages of the construction process to demonstrate code compliance. The activity then progresses to translating these specifications into structured, machine-readable formats and implementing them within the NRC DCP system. This process will involve defining what information is required, when it's needed, and in what format it should be provided to demonstrate compliance. The implementation will support automated code checking, streamline the regulatory compliance process, and enhance the efficiency and accuracy of code checking procedures throughout the construction lifecycle.

Target / Deliverables

Comprehensive IDS package including: Set of developed Information Delivery Specifications for key code requirements, Implementation documentation detailing how IDS are integrated into the NRC DCP, Library of machine-readable IDS for automated compliance checking, User guides for both IDS development and utilization, Example use cases demonstrating IDS application in various scenarios, Performance metrics showing improvement in code checking efficiency

Responsible party

Activity type: Initial resource development

Scenario: NMCC

CDF Resource: Process

Predecessor:

- 2.1.03
- 2.1.04
- 2.1.05
- 1.2.12

1. Digital Resources

Activity ID: 1.2.13

1.2 Supporting Resourc

Implement semantic web technologies (e.g., RDF, OWL) for enhanced content relationships

Phase 2 (2026-2027):

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity involves implementing semantic web technologies to create a more interconnected and intelligent content ecosystem. It includes converting key content into RDF (Resource Description Framework) format, developing OWL (Web Ontology Language) ontologies to represent complex relationships, and implementing SPARQL endpoints for advanced querying. This will enable more sophisticated content linking and knowledge discovery within the platform.

Target / Deliverables

Semantic web layer for NRC DCP, including RDF datasets, OWL ontologies, SPARQL endpoints, and integration documentation.

Responsible party

Activity type: Resource adoption and adaptation

Scenario: General

CDF Resource: Syntax

Predecessor:

1. Digital Resources

Activity ID: 1.2.14

1.2 Supporting Resourc

Extend IM specifications to support automated zoning checks and local management by municipalities

Phase 2 (2026-2027):

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity focuses on enhancing Information Model (IM) specifications to support automated zoning checks and enable local management by municipalities. It involves extending existing IM schemas to incorporate zoning-specific data, developing rule sets for zoning compliance checks, and creating interfaces for municipal authorities to manage local variations. This will facilitate more efficient and consistent zoning compliance processes across different jurisdictions.

Target / Deliverables

Extended IM specifications for zoning, including enhanced data schemas, automated check rule sets, and municipal management interfaces.

Responsible party

Activity type: Resource adoption and adaptation

Scenario: NMCC

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.2.16

1.2 Supporting Resourc

Refine and expand supporting resources based on user feedback

Phase 3 (2028-2030)

Start Date: 2029-07-01

End Date: 2030-04-30

Duration: 9 months

Decription

This activity involves an iterative process of refining and expanding the supporting resources of the NRC DCP based on user feedback and observed usage patterns. It includes conducting user surveys, analyzing platform analytics, and implementing improvements to various resources such as templates, guidelines, and tools. This ongoing refinement ensures the platform continues to meet the evolving needs of its users.

Target / Deliverables

Updated resource suite, including refinement report detailing user feedback, implemented changes, and impact assessment.

Responsible party

Activity type: Advanced resource development

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.2.17

1.2 Supporting Resourc

Adopt/Develop advanced ontologies for specific domains (e.g., energy efficiency, accessibility)

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on adopting or developing advanced ontologies for specialized domains relevant to the built environement, such as energy efficiency and accessibility. It involves evaluating existing domain-specific ontologies, extending them to meet NRC DCP requirements, and developing new ontologies where gaps exist. These advanced ontologies will enable more nuanced representation and analysis of domain-specific concepts within the platform.

Target / Deliverables

Suite of domain-specific ontologies, including adoption/development rationale, integration guidelines, and usage examples.

Responsible party

Activity type: Advanced resource development

Scenario: General

CDF Resource: Semantics

Predecessor:

1. Digital Resources

Activity ID: 1.2.18

1.2 Supporting Resourc

Design custom dictionaries for Canadian-specific terminologies

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2028-01-01

Duration: 24 months

Decription

This activity involves creating specialized dictionaries that capture Canadian-specific construction terminologies and concepts. It includes identifying terms unique to the Canadian context, defining them precisely, and establishing relationships with international standard terms where applicable. This work ensures that the NRC DCP accurately represents Canadian construction language and practices, facilitating clear communication and precise interpretation of standards and regulations.

Target / Deliverables

Custom Canadian construction terminology dictionary, including term definitions, usage contexts, and mappings to international standards.

Responsible party

Activity type: Initial resource development

Scenario: General

CDF Resource: Semantics

Predecessor:

1. Digital Resources

Activity ID: 1.2.19

1.2 Supporting Resourc

Implement advanced classification systems for emerging technologies

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on developing and implementing classification systems that can accommodate rapidly evolving construction technologies. It involves creating flexible taxonomies that can incorporate new materials, methods, and smart building technologies as they emerge. This forward-looking approach ensures the NRC DCP remains relevant and capable of representing cutting-edge construction practices.

Target / Deliverables

Advanced classification system for emerging technologies, with implementation guidelines and update protocols.

Responsible party

Activity type: Advanced resource development

Scenario: General

CDF Resource: Semantics

Predecessor:

1. Digital Resources

Activity ID: 1.2.20

1.2 Supporting Resourc

Develop tools for automatic classification and ontology mapping

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves creating intelligent tools that can automatically classify new content and map it to existing ontologies within the NRC DCP. It includes developing machine learning algorithms for content analysis, creating interfaces for semi-automated classification, and implementing validation processes to ensure accuracy. These tools will streamline the content management process and maintain consistency across the platform.

Target / Deliverables

Suite of automatic classification and ontology mapping tools, including user interfaces, algorithm documentation, and accuracy reports.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.3.01

1.3 Digital Processes

Confirm current content development and curation workflows for NMCC, NMS, and CCMC

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves a comprehensive review and documentation of existing workflows for content development and curation across NMCC, NMS, and CCMC. It includes mapping current processes, identifying key stakeholders and their roles, and highlighting areas where digitalization could improve efficiency. This foundational work ensures that the digital transformation preserves essential workflow elements while identifying opportunities for enhancement.

Target / Deliverables

Detailed workflow documentation for NMCC, NMS, and CCMC, including process maps, stakeholder matrices, and digitalization opportunity analysis.

Responsible party

Activity type: Process and workflow cataloging anc

Scenario: General

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.3.02

1.3 Digital Processes

Design digital workflow diagrams for content development, curation, and distribution processes

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-07-01

Duration: 6 months

Decription

Building on the current workflow analysis, this activity focuses on designing new digital workflows. It involves creating detailed BPMN (Business Process Model and Notation) diagrams that illustrate how content will be developed, curated, and distributed in the digital environment. These diagrams will serve as blueprints for implementing new digital processes and training staff on new procedures.

Target / Deliverables

Set of BPMN diagrams for digital content workflows, including detailed process descriptions and transition plans from current to future states.

Responsible party

Activity type: Process and workflow design and de

Scenario: General

CDF Resource: Process

Predecessor:

- 1.3.01

1. Digital Resources

Activity ID: 1.3.03

1.3 Digital Processes

Design initial digital workflow for CCMC product assessment and validation

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves creating a specialized digital workflow for CCMC product assessment and validation processes. It includes mapping the steps from product submission to final approval, identifying points for automated checks, and designing interfaces for assessor input. This digital workflow will streamline the product evaluation process, improving efficiency and consistency.

Target / Deliverables

Digital workflow design for CCMC product assessment, including process diagram, automation points, and user interface mockups.

Responsible party

Activity type: Process and workflow design and de

Scenario: CCMC

CDF Resource: Process

Predecessor:

- 1.3.01
- 1.3.02

1. Digital Resources

Activity ID: 1.3.04

1.3 Digital Processes

Identify opportunities for process optimization and digitalization

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves a comprehensive analysis of existing processes across NMCC, NMS, and CCMC to identify areas where digitalization can bring significant improvements. It includes conducting stakeholder interviews, analyzing process metrics, and benchmarking against international best practices. The goal is to pinpoint processes that can be streamlined, automated, or enhanced through digital technologies, setting the stage for targeted improvements.

Target / Deliverables

Process optimization report, including identified opportunities, potential impact assessments, and prioritized recommendations for digitalization.

Responsible party

Activity type: Process and workflow optimization

Scenario: General

CDF Resource: *delivery

Predecessor:

- 1.3.01

1. Digital Resources

Activity ID: 1.3.05

1.3 Digital Processes

Develop initial Information Delivery Manuals (IDMs) for key processes, following ISO 29481

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on creating Information Delivery Manuals for critical processes within the NRC DCP, adhering to ISO 29481 standards. It involves mapping information requirements, exchange requirements, and process maps for key workflows. These IDMs will serve as standardized guides for information exchange, ensuring consistency and completeness in data sharing across the platform.

Target / Deliverables

Set of Information Delivery Manuals for key NRC DCP processes, including detailed exchange requirements and process maps.

Responsible party

Activity type: Process and workflow design and de

Scenario: General

CDF Resource: Process

Predecessor:

- 1.3.01

1. Digital Resources

Activity ID: 1.3.06

1.3 Digital Processes

Establish initial quality control measures for digital content and processes

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-10-01

Duration: 9 months

Decription

This activity involves developing and implementing a set of quality control measures for the newly digitalized content and processes. It includes defining quality metrics, establishing review procedures, and creating automated validation checks. These measures will ensure the accuracy, consistency, and reliability of digital content and processes within the NRC DCP.

Target / Deliverables

Quality control framework document, including defined metrics, review protocols, and automated check specifications.

Responsible party

Activity type: Process and workflow monitoring and

Scenario: General

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.3.07

1.3 Digital Processes

Implement digital workflows for NMS content development, curation, and distribution

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

Building on the previously designed digital workflows, this activity involves the actual implementation of these workflows for NMS content. It includes configuring workflow management software, integrating with content management systems, and training staff on new procedures. This implementation will streamline the NMS content lifecycle, from initial development through to distribution.

Target / Deliverables

Digital workflow system for NMS, including system documentation, user guides, and performance metrics.

Responsible party

Activity type: Process and workflow design and de

Scenario: NMS

CDF Resource: Process

Predecessor:

- 1.3.02

1. Digital Resources

Activity ID: 1.3.08

1.3 Digital Processes

Develop automated processes for CCMC product assessment and validation

Phase 2 (2026-2027)

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on creating automated processes to support CCMC product assessment and validation. It involves developing algorithms for initial product data validation, creating automated testing protocols where applicable, and implementing systems for tracking assessment progress. These automated processes will increase efficiency and consistency in product evaluations.

Target / Deliverables

Suite of automated tools for CCMC product assessment, including data validation algorithms, testing protocols, and progress tracking system.

Responsible party

Activity type: Process and workflow optimization

Scenario: CCMC

CDF Resource: Process

Predecessor:

- 1.3.03

1. Digital Resources

Activity ID: 1.3.09

1.3 Digital Processes

Develop workflow for integrating CCMC committee processes (Stakeholder, Scheme, Appeals, Impartiality) into NRC DCP

Phase 2 (2026-2027)

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves creating digital workflows that integrate the various CCMC committee processes into the NRC DCP. It includes designing collaborative spaces for committee deliberations, implementing voting and decision-recording mechanisms, and ensuring proper documentation of committee activities. This integration will enhance transparency and efficiency in CCMC's governance processes.

Target / Deliverables

Integrated digital workflow for CCMC committees within the NRC DCP, including collaboration tools, decision-making mechanisms, and activity logging systems.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: CCMC

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.3.10

1.3 Digital Processes

Develop workflow for integrating NMS committee processes into NRC DCP

Phase 2 (2026-2027)

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves creating digital workflows to incorporate NMS committee processes into the NRC DCP. It includes designing collaborative spaces for committee members to review and update specifications, implementing version control systems for collaborative editing, and establishing approval processes within the digital environment. This integration will streamline the NMS development and update process, ensuring more efficient and transparent collaboration.

Target / Deliverables

Integrated digital workflow for NMS committees within the NRC DCP, including collaboration tools, version control systems, and approval process documentation.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: NMS

CDF Resource: Process

Predecessor:

- 1.3.02

1. Digital Resources

Activity ID: 1.3.11

1.3 Digital Processes

Establish digital workflows for NMCC updates, including public review process

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on developing digital workflows to manage the NMCC update process, including the public review component. It involves creating systems for proposing and tracking code changes, implementing digital platforms for public comment submission and review, and establishing workflows for incorporating feedback into the code update process. This will enhance the efficiency and transparency of the NMCC development process.

Target / Deliverables

Digital workflow system for NMCC updates, including change proposal tracking, public review platform, and feedback incorporation processes.

Responsible party

Activity type: Process and workflow design and de

Scenario: NMCC

CDF Resource: Process

Predecessor:

- 1.3.02

1. Digital Resources

Activity ID: 1.3.12

1.3 Digital Processes

Integrate digital processes with NRC DCP, ensuring interoperability

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves ensuring that all newly developed digital processes are fully integrated with the broader NRC DCP ecosystem. It includes establishing data exchange protocols between different systems and ensuring consistent user experiences across different processes. This integration is crucial for creating a cohesive and efficient digital platform.

Target / Deliverables

Integration report detailing interoperability achievements, including data exchange protocols, authentication systems, and user experience consistency measures.

Responsible party

Activity type: Process and workflow design and de

Scenario: General

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.3.13

1.3 Digital Processes

Implement process monitoring and optimization tools

Phase 2 (2026-2027):

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity focuses on developing and implementing tools to continuously monitor and optimize digital processes within the NRC DCP. It involves creating dashboards to track key performance indicators, implementing analytics tools to identify bottlenecks or inefficiencies, and establishing feedback mechanisms for ongoing process improvement. These tools will ensure the platform remains efficient and effective over time.

Target / Deliverables

Suite of process monitoring and optimization tools, including performance dashboards, analytics reports, and improvement recommendation systems.

Responsible party

Activity type: Process and workflow monitoring and

Scenario: General

CDF Resource: Process

Predecessor:

1. Digital Resources

Activity ID: 1.3.14

1.3 Digital Processes

Develop and implement quality assurance processes for all digital content and services

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2026-10-01

Duration: 9 months

Decription

Building on earlier quality control measures, this activity involves developing comprehensive quality assurance processes for all aspects of the NRC DCP. It includes establishing regular audit procedures, implementing user feedback systems, and creating protocols for continuous improvement of content and services. This will ensure the ongoing reliability and effectiveness of the platform.

Target / Deliverables

Quality assurance framework document, including audit procedures, feedback mechanisms, and continuous improvement protocols.

Responsible party

Activity type: Process and workflow monitoring and

Scenario: General

CDF Resource: Process

Predecessor:

- 1.3.06

1. Digital Resources

Activity ID: 1.3.15

1.3 Digital Processes

Implement continuous improvement processes for digital workflows

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves establishing systems and procedures for the ongoing refinement and enhancement of digital workflows within the NRC DCP. It includes implementing regular workflow reviews, establishing channels for user feedback on process efficiency, and creating mechanisms for testing and implementing workflow improvements. This ensures that the platform's processes remain optimized and aligned with user needs over time.

Target / Deliverables

Continuous improvement system for digital workflows, including review schedules, feedback channels, and improvement implementation protocols.

Responsible party

Activity type: Process and workflow optimization

Scenario: General

CDF Resource: Process

Predecessor:

- 1.3.13

1. Digital Resources

Activity ID: 1.3.16

1.3 Digital Processes

Develop advanced automation for content updates and distribution

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on creating sophisticated automation systems for updating and distributing content across the NRC DCP. It involves developing intelligent algorithms to identify content requiring updates, implementing automated workflows for content revision and approval, and creating systems for targeted content distribution based on user profiles and preferences. This advanced automation will ensure that the platform's content remains current and reaches the right stakeholders efficiently.

Target / Deliverables

Advanced content automation system, including update identification algorithms, automated revision workflows, and targeted distribution mechanisms.

Responsible party

Activity type: Process and workflow optimization

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.3.17

1.3 Digital Processes

Initiate creation of AI-powered process optimization tools

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2028-07-01

Duration: 6 months

Decription

This activity involves developing artificial intelligence tools to continually analyze and optimize processes within the NRC DCP. It includes implementing machine learning algorithms to identify process inefficiencies, creating predictive models for resource allocation, and developing AI-assisted decision-making tools for complex workflows. These AI-powered tools will enable the platform to adapt and improve its processes dynamically.

Target / Deliverables

Suite of AI-powered process optimization tools, including efficiency analysis algorithms, predictive resource allocation models, and AI-assisted decision support systems.

Responsible party

Activity type: Process and workflow optimization

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.3.18

1.3 Digital Processes

Investigate blockchain for secure and transparent process tracking

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity explores the potential of blockchain technology to enhance the security and transparency of critical processes within the NRC DCP. It involves assessing blockchain's applicability for tracking code changes, recording product certifications, and maintaining an immutable audit trail of regulatory decisions. The investigation will include feasibility studies, prototype development, and impact assessments.

Target / Deliverables

Blockchain feasibility report, including use case analyses, prototype results, and recommendations for implementation.

Responsible party

Activity type: Process and workflow design and de

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.3.19

1.3 Digital Processes

Develop predictive analytics for process optimization

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on creating predictive analytics capabilities to further optimize processes within the NRC DCP. It involves developing models to forecast resource needs, predict potential bottlenecks, and identify emerging trends in platform usage. These predictive capabilities will enable proactive management and continuous improvement of the platform's processes.

Target / Deliverables

Predictive analytics system for process optimization, including forecasting models, trend identification algorithms, and proactive management recommendations.

Responsible party

Activity type: Process and workflow optimization

Scenario: General

CDF Resource: Service

Predecessor:

1. Digital Resources

Activity ID: 1.3.20

1.3 Digital Processes

Implement advanced quality assurance and control mechanisms, including regular audits and automated validation checks

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

Building on earlier quality measures, this activity implements more sophisticated quality assurance and control mechanisms. It includes developing AI-driven content validation tools, implementing automated compliance checks for internal processes, and establishing regular, comprehensive platform audits. These advanced mechanisms will ensure the highest levels of quality and reliability across all aspects of the NRC DCP.

Target / Deliverables

Advanced quality assurance and control system, including AI-driven validation tools, automated compliance checks, and comprehensive audit protocols.

Responsible party

Activity type: Process and workflow monitoring and

Scenario: General

CDF Resource: Service

Predecessor:

- 1.3.14

2. Digital Platform

Activity ID: 2.1.01

2.1 Functions / Services

Confirm core platform requirements based on NMS, CCMC, and NMCC needs

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2025-07-01

Duration: 10 months

Decription

This activity involves a comprehensive review and confirmation of the core requirements for the NRC DCP, ensuring alignment with the specific needs of NMS, CCMC, and NMCC. Expected functionalities include developing core functions for the platform, such as implementing single sign-on capabilities across various platform components, and ensuring consistent user experiences across different processes. The activity includes conducting stakeholder workshops, analyzing user stories, and mapping functional and non-functional requirements. This foundational work will guide the subsequent development of platform features and services.

Target / Deliverables

Comprehensive platform requirements document, including functional and non-functional specifications, user stories, and prioritized feature list.

Responsible party

Activity type: Service cataloging and structuring

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.02

2.1 Functions / Services

Outline NMCC digital code management services

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2026-01-01

Duration: 9 months

Decription

This activity involves designing the core services for managing the digital version of the NMCC. It includes defining functionalities for code version control, change tracking, cross-referencing between code sections, and integration with compliance checking tools. The outline will consider user roles, access levels, and the need for real-time updates and notifications.

Target / Deliverables

Detailed outline of NMCC digital code management services, including functional specifications, user role definitions, and integration points with other platform components.

Responsible party

Activity type: Service cataloging and structuring

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.03

2.1 Functions / Services

Design initial Rule Configuration Service for managing and updating rulesets

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2026-01-01

Duration: 9 months

Decription

This activity focuses on creating a service that allows for the dynamic configuration and management of rulesets derived from the NMCC. It involves developing interfaces for rule creation, editing, and validation, as well as mechanisms for versioning and deploying rulesets. The service will be crucial for supporting automated compliance checking and adaptable regulatory frameworks.

Target / Deliverables

Design document for the Rule Configuration Service, including user interface mockups, rule structure definitions, and deployment workflow specifications.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.04

2.1 Functions / Services

Plan basic Compliance Checking Services for Land Use, Building Permit, and Urban Regulations, including permit application processing

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-07-01

Duration: 6 months

Decription

This activity involves planning the foundational compliance checking services that will be central to the NRC DCP. It includes defining the architecture for rule-based checking engines, designing workflows for permit application submission and processing, and outlining integration points with external systems such as municipal planning databases.

Target / Deliverables

Comprehensive plan for Compliance Checking Services, including system architecture diagrams, permit application workflows, and integration specifications.

Responsible party

Activity type: Service cataloging and structuring

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.05

2.1 Functions / Services

Design initial Information Requirements Service for permit applications and decision support, considering LOIN standards

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on designing a service that defines and manages the information requirements for permit applications, aligned with the Level of Information Need standard (ISO 7817). It involves creating structures for specifying required information at different project stages, developing mechanisms for validating submitted information, and designing decision support tools based on the completeness and quality of submitted data.

Target / Deliverables

Design specification for the Information Requirements Service, including data models aligned with LOIN standards, validation rule sets, and decision support logic flows.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.04

2. Digital Platform

Activity ID: 2.1.06

2.1 Functions / Services

Plan Zoning Requirements Service and Land Use Compliance Checking capabilities

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves planning services to digitize and standardize zoning requirements and to check compliance of proposed developments against these digital plans. It includes defining processes for converting various formats of land-use plans into a standardized digital format, and designing algorithms for automated checking of development proposals against these digital plans.

Target / Deliverables

Planning document for zoning conversion and compliance checking services, including format conversion specifications, standardized digital plan schema, and compliance checking algorithm outlines.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.07

2.1 Functions / Services

Plan Digital Specification services for NMS

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-07-01

Duration: 6 months

Decription

This activity focuses on planning services to digitize, manage, and utilize the NMS within the NRC DCP. It involves designing systems for converting specifications into machine-readable formats, creating tools for specification writing and customization, and developing mechanisms for linking specifications to other platform components such as product databases and code requirements.

Target / Deliverables

Comprehensive plan for NMS Digital Specification services, including digitization processes, specification management tools, and integration strategies with other platform components.

Responsible party

Activity type: Service design and development

Scenario: NMS

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.08

2.1 Functions / Services

Outline CCMC product assessment and validation services

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves designing digital services to support the CCMC product assessment and validation processes. It includes planning for digital submission portals, automated initial screening tools, workflow management for assessment processes, and systems for publishing and maintaining product evaluations. The services will aim to streamline the assessment process and improve accessibility of CCMC evaluations.

Target / Deliverables

Detailed outline of CCMC digital services, including functional specifications for submission, assessment, and publication processes, and integration points with other platform components.

Responsible party

Activity type: Service cataloging and structuring

Scenario: CCMC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.09

2.1 Functions / Services

Design initial user interface for central access point to published content, services, and resources

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-10-01

Duration: 9 months

Decription

This activity focuses on creating the design for the main user interface of the NRC DCP. It involves developing wireframes and mockups for the platform's dashboard, designing navigation structures for accessing various content types and services, and planning for personalized user experiences based on roles and preferences. The interface will serve as the primary point of interaction for all platform users.

Target / Deliverables

User interface design package, including wireframes, mockups, navigation maps, and user journey diagrams for the central access point of the NRC DCP.

Responsible party

Activity type: Service design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.10

2.1 Functions / Services

Design initial manufacturer submission portal for material applications

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2026-07-01

Duration: 6 months

Decription

This activity involves designing a dedicated portal for manufacturers to submit product information and applications for CCMC evaluation. It includes planning the user interface for data entry, document upload capabilities, progress tracking features, and integration with back-end assessment workflows. The portal will aim to simplify the submission process and improve communication between manufacturers and CCMC.

Target / Deliverables

Design specification for the manufacturer submission portal, including UI/UX designs, data input forms, document management features, and workflow integration points.

Responsible party

Activity type: Service design and development

Scenario: CCMC

CDF Resource: Service

Predecessor:

- 2.1.08

2. Digital Platform

Activity ID: 2.1.11

2.1 Functions / Services

Launch core DCP web portal (v1 alpha) with basic content access and search functions, including communication capabilities, and IFC file management for building applications

Phase 2 (2026-2027)

Start Date: 2027-01-01

End Date: 2027-07-01

Duration: 6 months

Decription

This activity involves developing and launching the first version of the core NRC DCP web portal. It includes implementing basic content access and search functionalities, setting up user authentication and authorization systems, developing communication tools for user support, and creating capabilities for managing IFC files for building applications. This alpha version will serve as a foundation for further development and user testing.

Target / Deliverables

NRC DCP web portal v1 alpha, including basic content access, search functionality, user guides, and preliminary IFC file management capabilities.

Responsible party

Activity type: Service design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.01

2. Digital Platform

Activity ID: 2.1.12

2.1 Functions / Services

Deliver core DCP functions (e.g., content management, user authentication and authorization)

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on implementing the essential backend functions necessary for the NRC DCP's operation. It includes setting up robust content management systems, implementing secure user authentication and authorization mechanisms, establishing data storage and retrieval systems, and creating logging and monitoring tools for platform operations. These core functions will form the backbone of the platform's infrastructure.

Target / Deliverables

Core DCP functions, including content management system, user authentication and authorization modules, data management systems, and operational monitoring tools.

Responsible party

Activity type: Service design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.01

2. Digital Platform

Activity ID: 2.1.13

2.1 Functions / Services

Implement NMCC digital code management services

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

Building on the earlier outline, this activity involves the full implementation of digital services for managing the NMCC. It includes developing version control systems, creating interfaces for code navigation and cross-referencing, implementing change tracking and notification systems, and integrating with compliance checking tools. These services will modernize the management and application of construction codes.

Target / Deliverables

NMCC digital code management system, including user interfaces for code navigation and editing, version control mechanisms, change tracking systems, and integration with compliance checking modules.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.02

2. Digital Platform

Activity ID: 2.1.14

2.1 Functions / Services

Develop and implement Rule Configuration Service

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves the full development and implementation of the Rule Configuration Service, based on the earlier design. It includes creating user interfaces for rule authoring and editing, developing a rule engine that can interpret and execute configured rules, implementing version control for rulesets, and integrating the service with other platform components such as the compliance checking modules. This service will enable dynamic updating of regulatory rules within the platform.

Target / Deliverables

Rule Configuration Service, including rule authoring interface, rule execution engine, version control system, and integration documentation with other platform services.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.03

2. Digital Platform

Activity ID: 2.1.15

2.1 Functions / Services

Implement basic Compliance Checking Services with automated code checks, BIM viewer integration, support for both Geospatial and BIM (IFC) data inputs, building permit application processing, automated creation and viewing of building permit applications, configuration of

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This comprehensive activity involves implementing a suite of compliance checking services. It includes developing automated code checking algorithms, integrating BIM viewers for visual inspections, creating modules to process both geospatial and BIM (IFC) data, implementing workflows for building permit applications, and developing tools for generating reports and BCF (BIM Collaboration Format) files. These services will form the core of the platform's regulatory compliance capabilities.

Target / Deliverables

Suite of Compliance Checking Services, including automated checking modules, integrated BIM viewer, data processing modules for geospatial and IFC inputs, permit application workflows, and reporting tools. User documentation and API specifications included.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.04

2. Digital Platform

Activity ID: 2.1.16

2.1 Functions / Services

Develop and implement Information Requirements Service and Building Permit Decision Support Service

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

Building on the earlier design, this activity involves fully developing the Information Requirements Service and a related Building Permit Decision Support Service. It includes creating systems to define, manage, and validate information requirements for different types of building permits, developing decision support algorithms to assist in permit evaluations, and implementing interfaces for both applicants and evaluators to interact with these services.

Target / Deliverables

Information Requirements Service and Building Permit Decision Support Service, including requirement management tools, validation mechanisms, decision support algorithms, and user interfaces for applicants and evaluators.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.05

2. Digital Platform

Activity ID: 2.1.17

2.1 Functions / Services

Develop and implement Zoning Requirements Service and Land Use Compliance Checking Service

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on creating services for digitizing zoning requirements compliance checking of proposed developments. It involves developing tools to convert various formats of land-use plans into a standardized digital format, creating a database to store and manage these digital plans, and implementing algorithms to automatically check proposed developments against applicable land-use regulations.

Target / Deliverables

Functional Zoning Requirements Conversion Service and Land Use Compliance Checking Service, including format conversion tools, digital plan database, automated checking algorithms, and user interfaces for plan management and compliance checking.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.06

2. Digital Platform

Activity ID: 2.1.18

2.1 Functions / Services

Build Digital Specification services for NMS

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves developing the full suite of digital services for the NMS. It includes creating tools for digitizing and structuring specification content, developing interfaces for specification writing and customization, implementing version control and change tracking for specifications, and creating integration points with product databases and code requirements.

Target / Deliverables

Digital Specification services for NMS, including content digitization tools, specification authoring and customization interfaces, version control system, and integration modules with related platform components.

Responsible party

Activity type: Service design and development

Scenario: NMS

CDF Resource: Service

Predecessor:

- 2.1.07

2. Digital Platform

Activity ID: 2.1.19

2.1 Functions / Services

Develop CCMC product assessment and validation services

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2027-07-01

Duration: 6 months

Decription

This activity involves implementing the digital services designed earlier for CCMC product assessment and validation. It includes developing the online submission portal for manufacturers, creating workflow management tools for assessors, implementing automated initial screening algorithms, and developing systems for publishing and maintaining digital product evaluations.

Target / Deliverables

Fully developed CCMC digital services, including manufacturer submission portal, assessor workflow tools, automated screening modules, and digital publication system for product evaluations.

Responsible party

Activity type: Service design and development

Scenario: CCMC

CDF Resource: Service

Predecessor:

- 2.1.08

2. Digital Platform

Activity ID: 2.1.20

2.1 Functions / Services

Develop basic analytics and reporting functionalities

Phase 2 (2026-2027)

Start Date: 2027-01-01

End Date: 2027-07-01

Duration: 6 months

Decription

This activity involves creating foundational analytics and reporting capabilities for the NRC DCP. It includes developing data aggregation and analysis tools, creating customizable dashboards for different user roles, implementing basic predictive analytics for trend identification, and designing standard and ad-hoc reporting features. These functionalities will provide valuable insights into platform usage, regulatory compliance trends, and industry patterns.

Target / Deliverables

Basic analytics and reporting module, including data aggregation tools, customizable dashboards, initial predictive analytics features, and a suite of standard reports with ad-hoc reporting capabilities.

Responsible party

Activity type: Service design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.09

2. Digital Platform

Activity ID: 2.1.21

2.1 Functions / Services

Implement initial web services for third-party access

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2027-07-01

Duration: 6 months

Decription

This activity focuses on developing and implementing a set of web services (APIs) that allow third-party applications to interact with the NRC DCP. It includes designing RESTful API endpoints, implementing authentication and authorization mechanisms for secure access, creating developer documentation, and setting up a sandbox environment for testing. These web services will facilitate integration with external systems and encourage ecosystem development around the platform.

Target / Deliverables

Initial set of web services (APIs) for third-party access, including API documentation, authentication/authorization systems, sandbox environment, and sample integration code.

Responsible party

Activity type: Service design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.09

2. Digital Platform

Activity ID: 2.1.22

2.1 Functions / Services

Implement feedback mechanism through the portal for continuous improvement

Phase 2 (2026-2027)

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity involves creating a comprehensive feedback system within the NRC DCP. It includes developing user interfaces for submitting feedback, implementing backend systems for categorizing and routing feedback to appropriate teams, creating dashboards for feedback analysis, and establishing workflows for addressing and implementing suggested improvements. This mechanism will ensure the platform evolves based on user needs and experiences.

Target / Deliverables

Implemented feedback system, including user submission interface, backend processing system, analysis dashboards, and improvement implementation workflows.

Responsible party

Activity type: Service design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.09

2. Digital Platform

Activity ID: 2.1.23

2.1 Functions / Services

Implement manufacturer submission portal for material applications

Phase 2 (2026-2027):

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

Building on the earlier design, this activity involves fully developing and implementing the portal for manufacturers to submit product information and applications for CCMC evaluation. It includes creating user registration and profile management systems, developing intuitive interfaces for data entry and document uploads, implementing progress tracking features, and integrating with backend assessment workflows.

Target / Deliverables

Manufacturer submission portal, including user management system, data submission interfaces, document management features, application tracking system, and integration with CCMC assessment workflows.

Responsible party

Activity type: Service design and development

Scenario: CCMC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.24

2.1 Functions / Services

Enhance Rule Configuration Service with AI-powered rule optimization

Phase 3 (2028-2030)

Start Date: 2028-07-01

End Date: 2030-04-30

Duration: 21 months

Decription

This activity focuses on incorporating artificial intelligence capabilities into the Rule Configuration Service. It involves developing machine learning algorithms to analyze rule effectiveness, implementing AI-assisted rule authoring tools, creating systems for automatic rule conflict detection and resolution, and developing predictive models for assessing the impact of rule changes. These enhancements will improve the efficiency and effectiveness of regulatory rule management.

Target / Deliverables

AI-enhanced Rule Configuration Service, including machine learning-based rule analysis tools, AI-assisted authoring interface, automated conflict detection and resolution system, and rule impact prediction models.

Responsible party

Activity type: Advanced service delivery

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 1.3.17

2. Digital Platform

Activity ID: 2.1.25

2.1 Functions / Services

Implement advanced Compliance Checking Services with real-time updates, predictive analysis, and AI-assisted building permit processing

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves upgrading the Compliance Checking Services with advanced features. It includes implementing real-time rule updating mechanisms, developing predictive analysis tools to forecast compliance issues, creating AI-assisted systems for automating aspects of building permit processing, and enhancing visualization tools for complex compliance scenarios. These advanced services will significantly streamline the regulatory compliance process.

Target / Deliverables

Advanced Compliance Checking Services suite, including real-time rule update system, predictive compliance analysis tools, AI-assisted permit processing modules, and enhanced compliance visualization interfaces.

Responsible party

Activity type: Advanced service delivery

Scenario: NMCC

CDF Resource: Service

Predecessor:

- 2.1.15

2. Digital Platform

Activity ID: 2.1.26

2.1 Functions / Services

Deliver e-permitting processes integrated with provincial/municipal systems, including advanced decision support features

Phase 3 (2028-2030)

Start Date: 2029-07-01

End Date: 2030-04-30

Duration: 9 months

Decription

This activity involves developing and implementing a comprehensive e-permitting system that integrates with existing provincial and municipal systems. It includes creating standardized data exchange protocols, developing interfaces for seamless information flow between systems, implementing advanced decision support tools that consider multi-jurisdictional requirements, and creating user-friendly application processes for permit seekers. This integration will streamline the permitting process across different levels of government.

Target / Deliverables

E-permitting system, including data exchange protocols, inter-system interfaces, multi-jurisdictional decision support tools, and unified permit application portal. Documentation on integration with various provincial/municipal systems included.

Responsible party

Activity type: Advanced service delivery

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.27

2.1 Functions / Services

Develop and integrate advanced analytical tools (LCA, structural analysis, acoustic analysis, lighting analysis, energy analysis) with enhanced BIM-based compliance checking, analysis capabilities, and Green Building Compliance Checking

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This comprehensive activity focuses on developing and integrating a suite of advanced analytical tools into the platform. It involves creating modules such as Life Cycle Assessment (LCA), structural analysis, acoustic analysis, lighting analysis, and energy analysis, etc. These tools will be integrated with BIM-based compliance checking systems and include specific features for Green Building Compliance. The integration will provide a holistic approach to building design and compliance assessment.

Target / Deliverables

Suite of integrated advanced analytical tools, including LCA, structural, acoustic, lighting, and energy analysis modules. BIM integration documentation, enhanced compliance checking features, and Green Building Compliance tools included.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.28

2.1 Functions / Services

Investigate digital twin services for building lifecycle management

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves researching and prototyping digital twin services for comprehensive building lifecycle management. It includes exploring technologies for real-time data integration from IoT devices, developing simulation capabilities for predictive maintenance, creating interfaces for visualizing building performance data, and investigating integration points with other platform services. This investigation will lay the groundwork for future advanced building management capabilities.

Target / Deliverables

Digital twin investigation report, including technology assessment, prototype designs, data integration specifications, and recommendations for full-scale implementation. Proof-of-concept demonstrating key digital twin functionalities.

Responsible party

Activity type: Advanced service delivery

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.29

2.1 Functions / Services

Implement AI-powered decision support tools for code interpretation and application

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on developing advanced AI systems to assist in the interpretation and application of building codes. It involves training natural language processing models on code documents, developing context-aware recommendation systems for code application, creating interfaces for AI-assisted code query resolution, and implementing machine learning algorithms for continuous improvement of interpretation accuracy.

Target / Deliverables

AI-powered code interpretation and application system, including NLP-based code analysis tools, context-aware recommendation engine, AI-assisted query interface, and learning algorithm for ongoing improvement. User guide and performance metrics included.

Responsible party

Activity type: Advanced service delivery

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.30

2.1 Functions / Services

Develop virtual and augmented reality services for on-site code compliance checking and complex spatial regulations

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves creating VR and AR services to support on-site compliance checking and visualization of complex spatial regulations. It includes developing mobile AR applications for real-time code checking during construction, creating VR environments for immersive review of proposed designs against spatial regulations, and implementing 3D visualization tools for complex zoning requirements. These services will enhance the practical application and understanding of building codes and regulations.

Target / Deliverables

VR/AR compliance checking and visualization services, including mobile AR application for on-site use, VR environment for design review, and 3D visualization tools for spatial regulations. User manuals and integration guidelines with existing platform services included.

Responsible party

Activity type: Advanced service delivery

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.31

2.1 Functions / Services

Develop advanced simulation capabilities for testing regulatory scenarios

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves creating sophisticated simulation tools to test the impact of potential regulatory changes. It includes developing parametric modeling capabilities to represent various regulatory scenarios, implementing machine learning algorithms to predict outcomes of regulatory modifications, creating visualization tools for presenting simulation results, and integrating these capabilities with existing rule configuration services. These simulations will aid in evidence-based policy-making and regulatory refinement.

Target / Deliverables

Advanced regulatory simulation system, including parametric modeling tools, predictive algorithms, visualization interfaces, and integration with rule configuration services. User guide and case studies demonstrating the system's application included.

Responsible party

Activity type: Advanced service delivery

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.32

2.1 Functions / Services

Implement automated zoning checks incorporating BIM and GIS technologies

Phase 2 (2026-2027)

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity focuses on developing an automated system for zoning compliance checks that leverages both Building Information Modeling (BIM) and Geographic Information Systems (GIS) data. It involves creating data integration protocols between BIM and GIS systems, developing algorithms for spatial analysis of building designs against zoning regulations, implementing 3D visualization tools for zoning envelopes, and creating user interfaces for interactive zoning compliance verification.

Target / Deliverables

Automated zoning check system, including BIM-GIS data integration protocols, spatial analysis algorithms, 3D zoning envelope visualization tools, and interactive compliance verification interface. Technical documentation and user manual included.

Responsible party

Activity type: Service design and development

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.1.33

2.1 Functions / Services

Develop validation services for low-carbon construction materials, including basic Life Cycle Assessment (LCA) capabilities

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves creating specialized services for validating and assessing low-carbon construction materials. It includes developing a database of material properties and environmental impacts, implementing basic LCA calculation tools, creating interfaces for manufacturers to submit material data, and developing reporting tools to communicate the environmental performance of materials. These services will support the NRC's goals for promoting sustainable construction practices.

Target / Deliverables

Low-carbon material validation and LCA service, including material property database, LCA calculation engine, manufacturer data submission portal, and environmental performance reporting tools. Guidelines for material assessment and integration with CCMC processes included.

Responsible party

Activity type: Advanced service delivery

Scenario: CCMC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.01

2.2 Exchanges / Integra

Assess current systems, current data exchange methods. and integration points between NRC systems

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2025-03-31

Duration: 6 months

Decription

This activity involves a comprehensive review of existing NRC systems, their data exchange methods, and potential integration points. It includes mapping current system architectures, analyzing data formats and exchange protocols, identifying interoperability challenges, and assessing the readiness of various systems for integration with the DCP. This assessment will inform the integration strategy and highlight areas requiring development or modification.

Target / Deliverables

Detailed systems assessment report, including system architecture maps, data exchange protocol analysis, interoperability gap analysis, and recommendations for system integration and upgrades.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Semantics

Predecessor:

2. Digital Platform

Activity ID: 2.2.02

2.2 Exchanges / Integra

Identify external systems for integration (e.g., provincial/municipal CDEs,, national cadastre, building registry)

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity focuses on identifying and assessing external systems that should be integrated with the NRC DCP. It involves surveying provincial and municipal Common Data Environments (CDEs), evaluating national cadastre and building registry systems, and identifying other relevant external databases or platforms. The activity includes analyzing the data structures, exchange formats, and integration requirements for each identified system.

Target / Deliverables

External systems integration report, including a catalog of identified systems, analysis of their data structures and exchange formats, assessment of integration requirements, and prioritized list of systems for integration.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Semantics

Predecessor:

2. Digital Platform

Activity ID: 2.2.03

2.2 Exchanges / Integra

Define API requirements for NRC DCP

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2025-07-01

Duration: 3 months

Decription

This activity involves defining comprehensive API requirements for the NRC DCP to enable seamless integration with both internal and external systems. It includes identifying required API endpoints, determining data exchange formats, establishing authentication and authorization protocols, defining rate limiting and caching strategies, and outlining documentation standards. The requirements will consider both data consumption and data provision scenarios.

Target / Deliverables

API requirements specification document, including endpoint definitions, data format specifications, security protocols, performance considerations, and API documentation standards. Sample API calls and responses included.

Responsible party

Activity type: Resource cataloging and structuring

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.01
- 2.2.03

2. Digital Platform

Activity ID: 2.2.04

2.2 Exchanges / Integra

Develop integration strategy with focus on openCDE principles

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves creating a comprehensive integration strategy for the NRC DCP, emphasizing openCDE principles to ensure interoperability and data exchange across different systems. It includes defining standard data exchange formats, establishing protocols for secure information sharing, creating guidelines for API development and consumption, and outlining processes for managing shared resources across different CDEs. The strategy will prioritize open standards and extensibility to accommodate future needs.

Target / Deliverables

Information environment integration strategy, including data exchange standards, security protocols, API guidelines, and resource management processes. Implementation roadmap and best practices guide for openCDE integration included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: *delivery

Predecessor:

2. Digital Platform

Activity ID: 2.2.05

2.2 Exchanges / Integra

Create initial API specification document for core data exchange requirements

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on developing a detailed API specification document that outlines the core data exchange requirements for the NRC DCP. It involves defining API endpoints, request/response formats, authentication methods, error handling procedures, and rate limiting policies. The specification will cover all major functions of the platform, ensuring comprehensive integration capabilities.

Target / Deliverables

Comprehensive API specification document, including endpoint definitions, data models, authentication protocols, error codes, and usage examples. Swagger/OpenAPI documentation included for developer reference.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.06

2.2 Exchanges / Integra

Plan for interconnected environments to enhance collaboration and data exchange

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2025-12-31

Duration: 15 months

Decription

This activity involves developing a strategy for creating interconnected digital environments within the NRC DCP ecosystem. It includes mapping out collaboration touchpoints between different user groups (e.g., regulators, manufacturers, designers), defining data sharing protocols between different modules of the platform, and creating workflows that span across multiple environments. The plan will focus on enhancing overall system cohesion and user productivity.

Target / Deliverables

Strategy guiding implementation of interconnected environments, including collaboration framework, cross-module data sharing protocols, and multi-environment workflow designs. Visual maps of planned interconnections and use case scenarios included.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.07

2.2 Exchanges / Integra

Phase 2 (2026-2027):

Support connections between NRC departments' Information Systems (NMS, CCMC, NMCC)

Start Date: 2026-01-01

End Date: 2028-01-01

Duration: 24 months

Decription

This activity focuses on implementing robust connections between the information systems of different NRC departments, specifically NMS, CCMC, and NMCC. It involves developing data mapping between systems, creating data transformation services, implementing real-time synchronization mechanisms, and establishing governance protocols for shared data management. These connections will ensure consistency and efficiency across NRC's digital ecosystem.

Target / Deliverables

Interdepartmental connection implementation report, including data mapping documentation, transformation service specifications, synchronization mechanism details, and data governance protocols. Performance metrics and troubleshooting guide included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.2.01

2. Digital Platform

Activity ID: 2.2.08

2.2 Exchanges / Integra

Implement integrations with key external systems (e.g., provincial code authorities/municipal CDEs)

Phase 2 (2026-2027)

Start Date: 2027-09-01

End Date: 2027-12-31

Duration: 3 months

Decription

This activity involves developing and implementing integrations with crucial external systems, such as provincial code authorities and municipal Common Data Environments (CDEs). It includes creating data exchange interfaces, implementing security measures for external communications, developing data transformation services to ensure compatibility, and creating monitoring tools for integration health. These integrations will extend the reach and utility of the NRC DCP.

Target / Deliverables

External systems integration package, including interface specifications, security implementation details, data transformation service documentation, and integration monitoring tools. Integration testing results and maintenance guidelines included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Semantics

Predecessor:

- 2.2.02

2. Digital Platform

Activity ID: 2.2.09

2.2 Exchanges / Integra

Set data exchange protocols using standard formats (XML, JSON, IFC, CityGML) and implement support for Classification Systems (e.g., ISO 12006, Masterformat, Uniform).

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2026-07-01

Duration: 6 months

Decription

This comprehensive activity focuses on establishing and implementing standard data exchange protocols for the NRC DCP. It involves defining schemas for XML and JSON data exchanges, implementing support for IFC (Industry Foundation Classes) and CityGML formats, and integrating major classification systems. This standardization will ensure broad interoperability and align the platform with industry standards.

Target / Deliverables

Data exchange protocol implementation package, including XML/JSON schemas, IFC/CityGML support documentation, and classification system integration guides. Validation tools and example exchanges for each format/system included.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Syntax

Predecessor:

- 2.2.03
- 2.2.04

2. Digital Platform

Activity ID: 2.2.10

2.2 Exchanges / Integra

Develop and test RESTful APIs for external access to DCP services

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves creating and rigorously testing RESTful APIs that will allow external systems and applications to access NRC DCP services. It includes designing API endpoints for all major platform functionalities, implementing authentication and authorization mechanisms, creating comprehensive documentation, and conducting thorough testing including load testing and security audits. These APIs will be crucial for enabling third-party integrations and extending the platform's reach.

Target / Deliverables

Fully developed and tested RESTful API suite, including endpoint implementations, authentication system, comprehensive API documentation, test results report, and developer onboarding guide.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Syntax

Predecessor:

- 2.2.05

2. Digital Platform

Activity ID: 2.2.11

2.2 Exchanges / Integra

Implement security measures and access controls for all integrations

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on implementing robust security measures and access controls for all integration points of the NRC DCP. It involves developing a comprehensive security framework, implementing encryption for data in transit and at rest, creating fine-grained access control mechanisms, setting up audit logging systems, and establishing protocols for regular security reviews and updates. These measures will ensure the integrity and confidentiality of data across all integrations.

Target / Deliverables

Security and access control implementation package, including security framework documentation, encryption protocols, access control system specifications, audit logging tools, and security review procedures.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.12

2.2 Exchanges / Integra

Implement initial BIM integration capabilities for NMS and CCMC content

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves developing capabilities to integrate BIM with NMS and CCMC content. It includes creating mechanisms to link BIM objects with relevant specifications and product evaluations, developing tools for extracting BIM data to populate specification templates, and implementing visualization capabilities to showcase CCMC-evaluated products within BIM models.

Target / Deliverables

BIM integration module for NMS and CCMC, including object-specification linking tools, data extraction utilities for specification population, and BIM-based product visualization features. User guide and integration examples included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: NMS

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.13

2.2 Exchanges / Integra

Develop integrations for sharing regulatory publications between CCMC and other government agencies

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on creating integrations to facilitate the sharing of regulatory publications between CCMC and other relevant government agencies. It involves developing data sharing protocols, implementing version control mechanisms for shared documents, creating notification systems for updates, and establishing workflows for collaborative editing and review of shared publications. These integrations will enhance regulatory consistency and cooperation across agencies.

Target / Deliverables

Inter-agency regulatory publication sharing system, including data sharing protocols, version control implementation, update notification service, and collaborative editing tools. Guidelines for inter-agency collaboration and system usage included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: CCMC

CDF Resource: Semantics

Predecessor:

2. Digital Platform

Activity ID: 2.2.14

2.2 Exchanges / Integra

Expand API ecosystem to support broader range of third-party applications

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity involves enhancing and expanding the API ecosystem of the NRC DCP to support a wider range of third-party applications. It includes developing new API endpoints for additional platform functionalities, implementing more granular data access controls, creating SDKs (Software Development Kits) for popular programming languages, and establishing a developer portal with comprehensive resources. This expansion will encourage innovation and increase the platform's utility across the industry.

Target / Deliverables

Expanded API ecosystem, including new API endpoints, enhanced access control system, SDKs for multiple languages, and a fully-featured developer portal. API usage analytics tools and showcase of third-party integrations included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.15

2.2 Exchanges / Integra

Implement advanced interoperability features with external platforms

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity focuses on implementing sophisticated interoperability features to enhance integration with external platforms. It involves developing real-time data synchronization capabilities, implementing federated query systems for distributed data access, creating mechanisms for cross-platform workflow management, and establishing protocols for semantic data integration. These advanced features will position the NRC DCP as a central hub in a broader digital construction ecosystem.

Target / Deliverables

Advanced interoperability feature set, including real-time sync modules, federated query system, cross-platform workflow engine, and semantic integration tools. Interoperability performance metrics and case studies of complex integrations included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Semantics

Predecessor:

- 2.2.08

2. Digital Platform

Activity ID: 2.2.16

2.2 Exchanges / Integra

Develop real-time data synchronization across all integrated systems

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves implementing advanced real-time data synchronization capabilities across all systems integrated with the NRC DCP. It includes developing event-driven architectures for immediate data updates, implementing conflict resolution mechanisms for simultaneous edits, creating failover and recovery systems to ensure data integrity, and establishing monitoring tools for synchronization performance. This real-time capability will ensure all stakeholders always have access to the most current information.

Target / Deliverables

Real-time data synchronization system, including event-driven update mechanisms, conflict resolution protocols, failover and recovery procedures, and synchronization monitoring dashboard. Performance benchmarks and troubleshooting guide included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.17

2.2 Exchanges / Integra

Investigate distributed ledger technology for secure data exchange and traceability

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on exploring the potential of distributed ledger technology (such as blockchain) to enhance secure data exchange and traceability within the NRC DCP ecosystem. It involves conducting feasibility studies, developing proof-of-concept implementations for key use cases (e.g., immutable audit trails for regulatory decisions), assessing scalability and performance implications, and creating a roadmap for potential full-scale implementation.

Target / Deliverables

Distributed ledger technology investigation report, including feasibility analysis, proof-of-concept implementations, performance assessment results, and implementation roadmap. Recommendations for specific use cases and technology choices included.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.18

2.2 Exchanges / Integra

Create marketplace for third-party services and integrations

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves developing a digital marketplace within the NRC DCP where third-party developers can offer services and integrations that extend the platform's capabilities. It includes creating a submission and approval process for third-party offerings, implementing rating and review systems, developing revenue sharing models, and creating tools for users to easily discover and integrate these services. This marketplace will foster innovation and expand the platform's ecosystem.

Target / Deliverables

Operational third-party service marketplace, including submission portal, approval workflow system, rating and review mechanisms, billing and revenue sharing systems, and service discovery tools. Guidelines for third-party developers and user manual included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.19

2.2 Exchanges / Integra

Support comprehensive Digital Twin capabilities, integrating real-time building data

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on implementing comprehensive Digital Twin capabilities within the NRC DCP, integrating real-time data from buildings and construction sites. It involves developing data ingestion systems for IoT devices, creating real-time 3D visualization tools, implementing predictive modeling capabilities based on live data, and establishing interfaces for interactive scenario planning. These capabilities will enable advanced lifecycle management of built assets.

Target / Deliverables

Digital Twin system, including IoT data ingestion services, real-time 3D visualization engine, predictive modeling tools, and scenario planning interfaces. Implementation guide for connecting physical assets and case studies of Digital Twin applications included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.20

2.2 Exchanges / Integra

Develop advanced BIM-based code compliance checking workflows

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves creating sophisticated workflows for automated code compliance checking using Building Information Models. It includes developing rule interpretation engines that can process complex code requirements, creating mechanisms to map BIM elements to relevant code clauses, implementing visualization tools for compliance results, and establishing systems for managing exceptions and human overrides. These workflows will significantly streamline the compliance checking process.

Target / Deliverables

Advanced BIM-based compliance checking system, including rule interpretation engine, BIM-to-code mapping tools, compliance visualization interfaces, and exception management system. User guide for compliance checking workflows and performance metrics included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.21

2.2 Exchanges / Integra

Extend integrations with smart city platforms, IoT systems, and advanced external databases

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on expanding the NRC DCP's integration capabilities to encompass smart city platforms, Internet of Things (IoT) systems, and advanced external databases. It involves developing standardized interfaces for smart city data exchange, creating protocols for real-time IoT data ingestion and processing, and implementing advanced query capabilities for external knowledge bases. These integrations will position the NRC DCP as a key component in broader smart built environment ecosystems.

Target / Deliverables

Extended integration package, including smart city data exchange interfaces, IoT data processing protocols, and advanced external database query systems. Integration guides for each new system type and showcase of innovative use cases included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.2.22

2.2 Exchanges / Integra

Ensure interoperability with external systems used for environmental impact assessments and zoning checks

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on developing robust interoperability features with external systems specifically used for environmental impact assessments and zoning checks. It involves creating standardized data exchange formats for environmental and zoning data, implementing APIs for real-time data queries, developing integration tools for popular environmental assessment software, and creating visualization capabilities for zoning and environmental constraints within the NRC DCP. This interoperability will support more comprehensive and efficient planning and assessment processes.

Target / Deliverables

Interoperability package for environmental and zoning systems, including data exchange format specifications, API documentation, integration tools for key software, and visualization modules. Use case examples and integration guide for municipalities and environmental agencies included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: NMCC

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.01

2.3 Repositories

Evaluate current data storage solutions for NMS, CCMC, and NMCC

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves a comprehensive assessment of the existing data storage solutions used for the NMS, CCMC resources, and NMCC. It includes analyzing current database structures, evaluating performance metrics, assessing scalability and security features, and identifying limitations in the current systems. This evaluation will inform decisions on data storage upgrades or migrations for the NRC DCP.

Target / Deliverables

Data storage evaluation report, including current system architectures, performance analysis, scalability and security assessments, and recommendations for improvements or replacements. Comparison matrix of current systems against DCP requirements included.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.02

2.3 Repositories

Define requirements for centralized data repositories

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2025-07-01

Duration: 10 months

Decription

Based on the evaluation of current systems and the broader needs of the NRC DCP, this activity focuses on defining comprehensive requirements for centralized data repositories. It involves specifying performance requirements, outlining security and access control needs, defining data model requirements to support all planned DCP functionalities, and establishing criteria for scalability, redundancy, and disaster recovery. These requirements will guide the development or procurement of robust, future-proof data storage solutions.

Target / Deliverables

Centralized data repository requirements document, including performance specifications, security and access control requirements, data model specifications, scalability and redundancy criteria, and disaster recovery standards. Use case scenarios demonstrating required repository capabilities included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.03

2.3 Repositories

Design initial repository structure for digital content within NRC DCP

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves creating the initial design for the repository structure that will house all digital content within the NRC DCP. It includes developing a logical data model that accommodates all content types (codes, specifications, product data, etc.), designing a physical data model optimized for performance and scalability, creating metadata schemas to enhance searchability and relationships between content, and defining content lifecycle management processes within the repository.

Target / Deliverables

Initial repository structure design document, including logical and physical data models, metadata schema specifications, content lifecycle management processes, and data flow diagrams. Sample queries demonstrating planned data retrieval capabilities included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Semantics

Predecessor:

2. Digital Platform

Activity ID: 2.3.04

2.3 Repositories

Design initial database schemas for NMCC, NMS, and CCMC content

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on designing specialized database schemas for the specific content types of NMCC, NMS, and CCMC. It involves analyzing the unique structural requirements of each content type, designing normalized database schemas that support efficient querying and updating, developing data validation rules to ensure content integrity, and creating index strategies to optimize performance for common query patterns. These schemas will form the foundation for storing and managing core NRC DCP content.

Target / Deliverables

Database schema design package, including entity-relationship diagrams, table specifications, data validation rules, and indexing strategies for NMCC, NMS, and CCMC content. Sample SQL for common queries and data manipulation operations included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Conceptual

Predecessor:

2. Digital Platform

Activity ID: 2.3.05

2.3 Repositories

Deliver data migration plans for existing content

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves developing comprehensive plans for migrating existing content from current systems to the new NRC DCP repositories. It includes mapping data from legacy formats to new schemas, developing data cleaning and transformation scripts, creating validation processes to ensure data integrity during migration, and establishing rollback procedures in case of migration issues. The plan will also include strategies for handling historical data and maintaining continuity of service during the migration process.

Target / Deliverables

Data migration plan document, including data mapping specifications, transformation scripts, validation procedures, rollback protocols, and migration schedule. Risk assessment and mitigation strategies for the migration process included.

Responsible party

Activity type: Process and workflow design and de

Scenario: General

CDF Resource: *delivery

Predecessor:

2. Digital Platform

Activity ID: 2.3.06

2.3 Repositories

Implement version control system for digital content management and plan for archiving systems

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity focuses on implementing a robust version control system for all digital content within the NRC DCP and planning for long-term archiving. It involves selecting and configuring a version control system that can handle diverse content types, developing branching and merging strategies, creating workflows for content review and approval, and establishing archiving policies and procedures. This system will ensure traceability of changes and long-term preservation of all NRC DCP content.

Target / Deliverables

Version control system, including system configuration documentation, workflow diagrams for content management, user guides for version control operations, and archiving policy document. Training materials for content managers included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.07

2.3 Repositories

Plan for centralized regulatory document and resource management

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2025-12-31

Duration: 15 months

Decription

This activity involves developing a comprehensive plan for centralized management of all regulatory documents and resources within the NRC DCP. It includes designing a unified content repository structure, developing metadata schemas for enhanced searchability and cross-referencing, creating workflows for document lifecycle management, and establishing access control policies. This centralized approach will improve consistency and efficiency in regulatory document management.

Target / Deliverables

Centralized regulatory document management plan, including repository structure design, metadata schema specifications, lifecycle management workflows, and access control policies. Implementation roadmap and integration guidelines with other DCP components included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.08

2.3 Repositories

Fully implement centralized cloud-based data storage for NMS, CCMC, and NMCC content, including long-term archival storage for submitted models, integration with external databases, and cloud-based architecture for permitting services. Ensure integration with national

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2028-01-01

Duration: 24 months

Decription

This comprehensive activity involves the full implementation of a cloud-based data storage solution for all NRC DCP content. It includes setting up cloud infrastructure, migrating data to the new system, implementing backup and disaster recovery solutions, and establishing integrations with relevant external databases. The implementation will also include specific features for long-term archival of building models and a cloud architecture to support e-permitting services.

Target / Deliverables

Cloud-based data storage system, including infrastructure documentation, data migration report, backup and disaster recovery procedures, and integration specifications with external databases. Performance benchmarks and scaling guidelines included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.3.01
- 2.3.02
- 2.3.03
- 2.3.04

2. Digital Platform

Activity ID: 2.3.09

2.3 Repositories

Develop advanced search and retrieval mechanisms for all content types

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on creating sophisticated search and retrieval capabilities across all content types in the NRC DCP. It involves implementing full-text search engines, developing semantic search capabilities, creating faceted search interfaces, and implementing relevance ranking algorithms. The system will support complex queries across different content types and leverage metadata for enhanced search precision.

Target / Deliverables

Advanced search and retrieval system, including search engine implementation, semantic search capabilities, faceted search interface, and relevance ranking algorithms. User guide for advanced search features and performance metrics included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.10

2.3 Repositories

Implement data validation and integrity checks for all repositories

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves developing and implementing comprehensive data validation and integrity check systems for all NRC DCP repositories. It includes creating data validation rules, implementing real-time data quality checks, developing periodic data integrity audits, and creating tools for automated error detection and reporting. These measures will ensure the ongoing accuracy and reliability of all data within the platform.

Target / Deliverables

Data validation and integrity system, including validation rule sets, real-time check implementations, audit schedules and procedures, and error detection and reporting tools. Data quality dashboard and remediation process documentation included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.11

2.3 Repositories

Create backup and disaster recovery systems for all DCP data

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on implementing robust backup and disaster recovery systems for all data within the NRC DCP. It involves developing backup strategies (including frequency and retention policies), implementing geographically distributed backup storage, creating disaster recovery plans, and establishing regular testing procedures for recovery scenarios. This system will ensure data resilience and business continuity.

Target / Deliverables

Backup and disaster recovery system, including backup strategy documentation, implemented backup solutions, disaster recovery plans, and testing procedure guidelines. Recovery time objective (RTO) and recovery point objective (RPO) specifications included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.12

2.3 Repositories

Establish data access controls and user permission systems

Phase 2 (2026-2027)

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity involves creating a comprehensive system for managing data access controls and user permissions across the NRC DCP. It includes developing role-based access control (RBAC) models, implementing fine-grained permission systems, creating user authentication and authorization protocols, and developing audit logging for all data access activities. This system will ensure data security and appropriate access management.

Target / Deliverables

Data access control and user permission system, including RBAC model documentation, permission system implementation, authentication and authorization protocols, and audit logging mechanisms. User management interface and security audit procedures included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.13

2.3 Repositories

Develop initial data analytics capabilities for repository content

Phase 2 (2026-2027)

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity focuses on creating basic data analytics capabilities to gain insights from the content stored in NRC DCP repositories. It involves implementing data warehousing solutions, developing ETL (Extract, Transform, Load) processes, creating basic dashboards and reports, and implementing simple predictive analytics models. These capabilities will provide valuable insights into content usage and trends.

Target / Deliverables

Initial data analytics package, including data warehouse schema, ETL process documentation, set of standard dashboards and reports, and basic predictive models. User guide for analytics tools and sample insights report included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

- 2.1.20

2. Digital Platform

Activity ID: 2.3.14

2.3 Repositories

Develop structured information states for all content types

Phase 1 (2024-2025):

Start Date: 2025-07-01

End Date: 2026-01-01

Duration: 6 months

Decription

This activity involves aligning the NRC DCP content management processes with standardized Common Data Environment (CDE) states. It includes defining workflows for moving content through different states, implementing state-based access controls, creating notification systems for state changes, and developing archiving processes for content lifecycle management. This alignment will improve collaboration and content management efficiency.

Target / Deliverables

Information state description, including workflow diagrams for each content type, state-based access control rules, notification system specifications, and archiving process documentation. Guidelines for content managers on using CDE states included.

Responsible party

Activity type: Systems cataloging and structuring

Scenario: General

CDF Resource: Process

Predecessor:

2. Digital Platform

Activity ID: 2.3.15

2.3 Repositories

Implement advanced data analytics and reporting capabilities

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity builds upon the initial data analytics capabilities, implementing more sophisticated tools and techniques. It involves developing advanced machine learning models for predictive analytics, creating interactive data visualization tools, implementing real-time analytics processing, and developing customizable reporting interfaces. These advanced capabilities will provide deep insights into platform usage, regulatory trends, and industry patterns.

Target / Deliverables

Advanced analytics and reporting suite, including machine learning model documentation, interactive visualization tools, real-time analytics engine, and customizable reporting interface. User guide for advanced analytics features and sample advanced insights report included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Service

Predecessor:

- 2.3.13

2. Digital Platform

Activity ID: 2.3.16

2.3 Repositories

Develop predictive maintenance and optimization features for repositories

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on creating predictive maintenance capabilities for the NRC DCP repositories. It involves implementing AI-driven anomaly detection systems, developing predictive models for system performance, creating automated optimization routines for database performance, and implementing proactive alert systems for potential issues. These features will ensure optimal performance and reliability of the data repositories.

Target / Deliverables

Predictive maintenance and optimization system, including anomaly detection algorithms, performance prediction models, automated optimization scripts, and alert system documentation. Performance improvement case studies and maintenance schedule optimizer included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.17

2.3 Repositories

Implement AI-powered data quality and consistency checks

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves developing advanced, AI-powered systems for ensuring data quality and consistency across all NRC DCP repositories. It includes implementing machine learning models for detecting data anomalies, creating natural language processing tools for consistency in textual data, developing AI-assisted data cleaning tools, and implementing continuous learning mechanisms to improve data quality over time.

Target / Deliverables

AI-powered data quality system, including anomaly detection model documentation, NLP-based consistency checking tools, AI-assisted data cleaning interfaces, and continuous learning mechanism specifications. Data quality improvement metrics and case studies included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: Service

Predecessor:

2. Digital Platform

Activity ID: 2.3.18

2.3 Repositories

Produce knowledge graph of all NRC DCP data for advanced querying

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity focuses on creating a comprehensive knowledge graph representation of all data within the NRC DCP. It involves defining ontologies for different data domains, implementing graph database technologies, developing tools for populating and maintaining the knowledge graph, and creating advanced query interfaces that leverage the graph structure. This will enable sophisticated relationship-based querying and data exploration.

Target / Deliverables

NRC DCP knowledge graph system, including ontology definitions, graph database implementation documentation, graph population and maintenance tools, and advanced query interface. User guide for knowledge graph exploration and sample complex queries included.

Responsible party

Activity type: Systems implementation and optimiz

Scenario: General

CDF Resource: *delivery

Predecessor:

2. Digital Platform

Activity ID: 2.3.19

2.3 Repositories

Develop data lake architecture for big data analytics

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves implementing a data lake architecture to support big data analytics capabilities within the NRC DCP. It includes setting up distributed storage systems, implementing data ingestion pipelines for various data types, developing data cataloging and metadata management systems, and creating interfaces for data scientists to access and analyze the data lake contents. This architecture will support advanced analytics on large-scale, diverse datasets.

Target / Deliverables

Data lake architecture, including storage system configuration, data ingestion pipeline documentation, data catalog and metadata management tools, and data scientist access interfaces. Best practices guide for data lake usage and sample big data analytics use cases included.

Responsible party

Activity type: Systems design and development

Scenario: General

CDF Resource: Service

Predecessor:

3. Platform Delivery

Activity ID: 3.1.01

3.1 Project Managemen

Establish project steering committee and working groups for ongoing project governance

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves setting up the governance structure for the NRC DCP project. It includes defining the roles and responsibilities of the steering committee, establishing working groups for different aspects of the project, creating communication channels between groups, and developing decision-making processes. This governance structure will ensure clear direction and accountability throughout the project.

Target / Deliverables

Project governance structure document, including steering committee charter, working group definitions, communication protocol, and decision-making framework. Governance organization chart and meeting schedule included.

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.02

3.1 Project Managemen

Define governance structure including roles for NMS, CCMC, and NMCC stakeholders

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity focuses on creating a detailed governance structure that incorporates stakeholders from NMS, CCMC, and NMCC. It involves defining specific roles and responsibilities for each stakeholder group, establishing decision-making authorities, creating conflict resolution procedures, and developing mechanisms for ongoing stakeholder engagement. This structure will ensure balanced representation and effective collaboration across all key areas.

Target / Deliverables

Comprehensive governance structure document, including stakeholder role definitions, decision-making authority matrix, conflict resolution procedures, and stakeholder engagement plan. Stakeholder responsibility chart and governance process flows included.

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.03

3.1 Project Managemen

Develop project charter and high-level project plan aligned with PDCSS objectives

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves creating a comprehensive project charter and high-level plan for the NRC DCP, ensuring alignment with the Platform to Decarbonize the Construction Sector at Scale (PDCSS) objectives. It includes defining project scope, objectives, key deliverables, timelines, and resource requirements.

Target / Deliverables

Project charter and high-level project plan document with PDCSS alignment analysis.

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.04

3.1 Project Managemen

Create risk management and mitigation strategies for identified project risks

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-07-01

Duration: 6 months

Decription

This activity focuses on developing a robust risk management framework for the NRC DCP project. It involves identifying potential risks, assessing their impact and likelihood, developing mitigation strategies, and creating monitoring and response plans.

Target / Deliverables

Risk management and mitigation strategy document with risk register and response protocols.

Responsible party

Activity type: Project management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.06

3.1 Project Managemen

Develop initial change management processes for the DCP

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-07-01

Duration: 6 months

Decription

This activity involves creating change management processes to guide the implementation and adoption of the NRC DCP. It includes aligining strategies for stakeholder engagement, communication plans, training programs, and feedback mechanisms.

Target / Deliverables

Change management strategies and processes.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.07

3.1 Project Managemen

Phase 1 (2024-2025):

Implement project monitoring and reporting systems

Start Date: 2024-09-01

End Date: 2025-03-31

Duration: 6 months

Decription

This activity focuses on establishing systems for ongoing project monitoring and reporting. It involves setting up project management tools, defining key performance indicators (KPIs), creating reporting templates, and establishing regular review cycles.

Target / Deliverables

Project monitoring and reporting system with KPI dashboard and automated report generation capabilities.

Responsible party

Activity type: Project management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.08

3.1 Project Managemen

Phase 2 (2026-2027):

Conduct change management processes for the DCP

Start Date: 2026-01-01

End Date: 2028-01-01

Duration: 24 months

Decription

This activity involves executing the change management processes developed earlier. It includes implementing communication plans, conducting training sessions, managing stakeholder expectations, and addressing resistance to change.

Target / Deliverables

Change management execution report with stakeholder feedback analysis and adoption metrics.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

- 3.1.06

3. Platform Delivery

Activity ID: 3.1.09

3.1 Project Managemen

Establish long-term governance model for DCP operations

Phase 2 (2026-2027)

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity focuses on developing a sustainable governance model for the ongoing operation of the NRC DCP beyond the initial implementation. It includes defining long-term roles and responsibilities, establishing decision-making processes, and creating mechanisms for continuous improvement.

Target / Deliverables

Long-term DCP governance model document with operational guidelines and improvement processes.

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.10

3.1 Project Managemen

Integrate CCMC committees (Stakeholder, Scheme, Appeals, Impartiality) into NRC DCP workflow

Phase 2 (2026-2027):

Start Date: 2026-09-01

End Date: 2027-01-01

Duration: 4 months

Decription

This activity involves incorporating CCMC committee processes into the NRC DCP digital workflow. It includes mapping current committee processes, designing digital workflows, and implementing tools for committee collaboration and decision-making within the platform.

Target / Deliverables

Digital workflow system for CCMC committees with integrated collaboration tools.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: CCMC

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.12

3.1 Project Managemen

Implement advanced project portfolio management for ongoing DCP development

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2028-07-01

Duration: 6 months

Decription

This activity focuses on establishing sophisticated project portfolio management practices for continued DCP development. It involves implementing portfolio analysis tools, creating resource allocation strategies, and developing methods for prioritizing and balancing multiple DCP-related projects.

Target / Deliverables

Advanced project portfolio management system with resource optimization capabilities.

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

- 3.1.04

3. Platform Delivery

Activity ID: 3.1.13

3.1 Project Managemen

Transition from project-based to product-based management for ongoing DCP development

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2029-07-01

Duration: 6 months

Decription

This activity involves shifting the management approach from project-based to product-based for the DCP. It includes redefining team structures, establishing product ownership roles, and implementing agile methodologies for continuous delivery and improvement.

Target / Deliverables

Product-based management framework with agile process documentation.

Responsible party

Activity type: Project management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.14

3.1 Project Managemen

Implement advanced risk management and mitigation strategies for the operational platform

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity focuses on developing and implementing sophisticated risk management strategies for the operational DCP. It involves creating predictive risk models, implementing real-time risk monitoring systems, and developing rapid response protocols for emerging risks.

Target / Deliverables

Advanced risk management system with predictive modeling and real-time monitoring capabilities.

Responsible party

Activity type: Project management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.15

3.1 Project Managemen

Develop international partnerships for knowledge exchange and potential platform expansion

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity involves establishing partnerships with international organizations for knowledge sharing and exploring opportunities for platform expansion. It includes identifying potential partners, developing collaboration frameworks, and creating knowledge exchange programs.

Target / Deliverables

International partnership strategy with collaboration agreements and knowledge exchange protocols.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.16

3.1 Project Managemen

Develop long-term strategic plan for DCP evolution and sustainability

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity focuses on creating a comprehensive long-term strategy for the evolution and sustainability of the DCP. It includes forecasting technological trends, planning for scalability, and developing sustainable funding models.

Target / Deliverables

Long-term DCP strategic plan

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.17

3.1 Project Managemen

Design governance model for third-party contributions and open-source components

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2028-07-01

Duration: 6 months

Decription

This activity involves developing a governance model to manage third-party contributions and the integration of open-source components into the DCP. It includes creating contribution guidelines, establishing review processes, and developing licensing strategies.

Target / Deliverables

Governance model with open-source integration guidelines for third-party contribution .

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.1.18

3.1 Project Managemen

Establish mechanism for ongoing evaluation and improvement of NRC DCP's tools and processes

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2028-07-01

Duration: 6 months

Decription

This activity focuses on creating systems for continuous evaluation and improvement of the DCP's tools and processes. It involves implementing user feedback mechanisms, establishing regular review cycles, and developing improvement prioritization methods.

Target / Deliverables

Continuous improvement system with user feedback integration and improvement tracking tools.

Responsible party

Activity type: Project governance

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.01

3.2 Capability Developn

Conduct skills assessment of NRC staff across departments

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2025-09-01

Duration: 12 months

Decription

This activity involves assessing the current skill levels of NRC staff in relation to DCP requirements. It includes developing assessment criteria, conducting evaluations, and identifying skill gaps across departments.

Target / Deliverables

Comprehensive skills assessment report with gap analysis.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.02

3.2 Capability Developn

Identify skill gaps for DCP development and operation

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

Building on the skills assessment, this activity focuses on pinpointing specific skill gaps critical for DCP development and operation. It involves analyzing assessment results, consulting with subject matter experts, and prioritizing skill development needs.

Target / Deliverables

Skill gap analysis report with prioritized development recommendations.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

- 3.2.01

3. Platform Delivery

Activity ID: 3.2.03

3.2 Capability Developn

Develop training plans for key technologies and methodologies (e.g., BIM, Data management/Linked Data)

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2026-07-01

Duration: 6 months

Decription

This activity involves creating comprehensive training plans to address identified skill gaps. It includes designing curricula, selecting training methods, and developing assessment criteria for key technologies and methodologies.

Target / Deliverables

Training plan document with curricula outlines and assessment criteria.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

- 3.2.03

3. Platform Delivery

Activity ID: 3.2.04

3.2 Capability Developn

Design capacity building strategy for NRC teams

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity focuses on developing a holistic strategy for building the capacity of NRC teams to support the DCP. It includes creating mentorship programs, establishing knowledge sharing mechanisms, and designing career development pathways.

Target / Deliverables

Capacity building strategy document with implementation roadmap.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.05

3.2 Capability Developn

Plan for ongoing education programs for external stakeholders

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity involves developing educational programs to support external stakeholders in effectively using and contributing to the DCP. It includes designing online courses, creating user guides, and planning workshops and webinars.

Target / Deliverables

Educational program plans with course outlines and delivery schedules for external stakeholder

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.06

3.2 Capability Developn

Begin creating user guides for early DCP components

Phase 1 (2024-2025):

Start Date: 2025-04-01

End Date: 2026-01-01

Duration: 9 months

Decription

This activity involves developing initial user guides for the first components of the DCP. It includes identifying key user groups, creating step-by-step instructions, and developing troubleshooting guides.

Target / Deliverables

Initial set of user guides for early DCP components.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.07

3.2 Capability Developn

Establish knowledge sharing mechanisms within the project team

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2027-01-01

Duration: 12 months

Decription

This activity focuses on creating systems and processes for effective knowledge sharing among project team members. It involves setting up collaboration tools, organizing regular knowledge exchange sessions, and creating a central knowledge repository.

Target / Deliverables

Knowledge sharing system with collaboration tools and repository.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.08

3.2 Capability Developn

Roll out training programs for NRC staff on new digital systems and processes

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves implementing the training programs developed earlier for NRC staff. It includes conducting training sessions, providing hands-on practice opportunities, and assessing learning outcomes.

Target / Deliverables

Training program with attendance records and assessment results.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.09

3.2 Capability Developn

Develop user guides and documentation for NRC DCP

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on creating comprehensive user guides and documentation for all aspects of the NRC DCP. It includes developing detailed manuals, creating quick-start guides, and producing video tutorials.

Target / Deliverables

Complete set of user guides and documentation for NRC DCP.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.10

3.2 Capability Developn

Phase 2 (2026-2027)

Develop e-learning modules for external stakeholders (e.g., industry professionals, regulators)

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves creating online learning modules tailored for external stakeholders. It includes designing interactive courses, developing assessment tools, and creating a learning management system.

Target / Deliverables

E-learning platform with stakeholder-specific modules.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.11

3.2 Capability Developn

Establish help desk and support system for DCP users

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on setting up a comprehensive support system for DCP users. It involves implementing ticketing systems, creating knowledge bases, and establishing support team protocols.

Target / Deliverables

Help desk and support system for DCP users.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.12

3.2 Capability Developn

Implement continuous learning program for evolving digital skills

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves developing a program to ensure ongoing skill development as digital technologies evolve. It includes creating skill roadmaps, implementing micro-learning opportunities, and establishing partnerships with technology providers for training.

Target / Deliverables

Continuous learning program with skill development tracking system.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.13

3.2 Capability Developm

Establish communities of practice around key DCP technologies

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on fostering communities of practice for key technologies used in the DCP. It involves identifying community leaders, setting up collaboration platforms, and organizing regular community events.

Target / Deliverables

Communities of practice with engagement metrics are established.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.14

3.2 Capability Developn

Develop training programs for effective utilization of analytical tools and automated checks

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves creating specialized training programs for the use of advanced analytical tools and automated checks within the DCP. It includes developing hands-on workshops, creating use case scenarios, and implementing proficiency assessments.

Target / Deliverables

Training program for analytical tools and automated checks.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.15

3.2 Capability Developn

Implement advanced digital skills development program for NRC staff

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on implementing a comprehensive program for developing advanced digital skills among NRC staff. It includes creating personalized learning paths, implementing mentorship programs, and organizing hackathons and innovation challenges.

Target / Deliverables

Advanced digital skills development program with progress tracking tools.

Responsible party

Activity type: Change management

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.16

3.2 Capability Developn

Develop industry-wide certification programs for NRC DCP proficiency

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves creating certification programs to recognize and validate proficiency in using the NRC DCP. It includes defining certification levels, developing assessment criteria, and establishing a certification process.

Target / Deliverables

Industry-wide NRC DCP certification program.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.17

3.2 Capability Developn

Establish mentorship program for knowledge transfer within NRC

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on creating a structured mentorship program to facilitate knowledge transfer within NRC. It includes identifying mentors, matching mentors with mentees, and developing mentorship guidelines and resources.

Target / Deliverables

Mentorship program with matching system and guidelines.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.18

3.2 Capability Developn

Establish center of excellence for digital construction practices

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves setting up a center of excellence focused on digital construction practices. It includes defining the center's mission and scope, assembling a team of experts, and developing a research and innovation agenda.

Target / Deliverables

Center of excellence for digital construction practices.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.19

3.2 Capability Developn

Develop collaborative research programs with academic institutions

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on establishing research collaborations with academic institutions to drive innovation in digital construction. It includes identifying research partners, defining research projects, and establishing funding and resource-sharing agreements.

Target / Deliverables

Collaborative research program with academic partnerships.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.2.20

3.2 Capability Developn

Set-up innovation labs for ongoing research and development in digital construction

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves creating dedicated innovation labs for continuous R&D in digital construction. It includes designing lab spaces, acquiring necessary equipment and technologies, and establishing research protocols.

Target / Deliverables

Innovation labs for digital construction R&D.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.01

3.3 Communications

Develop comprehensive stakeholder engagement plan

Phase 1 (2024-2025):

Start Date: 2024-09-01

End Date: 2024-12-31

Duration: 3 months

Decription

This activity involves creating a detailed plan for engaging all relevant stakeholders throughout the DCP development and implementation process. It includes identifying key stakeholders, developing engagement strategies, and creating communication plans.

Target / Deliverables

Comprehensive stakeholder engagement plan and strategy.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.02

3.3 Communications

Produce communication strategy for internal and external stakeholders

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2025-10-01

Duration: 9 months

Decription

This activity focuses on developing a robust communication strategy to keep both internal and external stakeholders informed about the DCP project. It includes creating messaging frameworks, selecting communication channels, and developing content calendars.

Target / Deliverables

Communication strategy with messaging frameworks and channel plans.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.03

3.3 Communications

Design awareness campaign materials about NRC DCP initiative

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity involves creating a suite of materials to raise awareness about the NRC DCP initiative. It includes developing brochures, presentations, videos, and social media content.

Target / Deliverables

Suite of awareness campaign materials for NRC DCP initiative.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.04

3.3 Communications

Establish feedback mechanisms for continuous improvement

Phase 1 (2024-2025):

Start Date: 2025-01-01

End Date: 2026-01-01

Duration: 12 months

Decription

This activity focuses on implementing systems to gather and act on feedback for ongoing improvement of the DCP. It includes setting up surveys, feedback portals, and processes for incorporating user suggestions.

Target / Deliverables

Operational feedback system with analysis and implementation protocols.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.05

3.3 Communications

Plan and execute kick-off events for key stakeholder groups

Phase 1 (2024-2025):

Start Date: 2025-09-01

End Date: 2025-12-31

Duration: 3 months

Decription

This activity involves organizing and conducting kick-off events to introduce the DCP to various stakeholder groups. It includes planning event agendas, preparing presentations, and coordinating logistics.

Target / Deliverables

Kick-off events with attendance records and feedback summaries.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.06

3.3 Communications

Expand stakeholder engagement to include broader industry groups

Phase 2 (2026-2027):

Start Date: 2026-01-01

End Date: 2028-01-01

Duration: 24 months

Decription

This activity focuses on extending engagement efforts to a wider range of industry stakeholders. It includes identifying new stakeholder groups, developing tailored engagement strategies, and creating industry partnership programs.

Target / Deliverables

Expanded stakeholder engagement plan with new industry partnerships.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.07

3.3 Communications

Develop and distribute educational materials about the NRC DCP

Phase 2 (2026-2027):

Start Date: 2027-07-01

End Date: 2028-01-01

Duration: 6 months

Decription

This activity involves creating and disseminating a variety of educational materials about the DCP. It includes developing fact sheets, whitepapers, case studies, and interactive online resources.

Target / Deliverables

Comprehensive set of educational materials about NRC DCP.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

- 3.2.14

3. Platform Delivery

Activity ID: 3.3.08

3.3 Communications

Develop case studies and success stories from early DCP adoption

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on documenting and sharing success stories from early adopters of the DCP. It includes conducting interviews, gathering data, and creating compelling narratives.

Target / Deliverables

Collection of case studies and success stories from early DCP adoption.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.09

3.3 Communications

Plan and execute industry events to showcase DCP capabilities

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves organizing events to demonstrate the capabilities of the DCP to industry stakeholders. It includes planning demonstrations, preparing presenters, and coordinating event logistics.

Target / Deliverables

Industry showcase events with attendee feedback analysis.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.10

3.3 Communications

Establish feedback loop for continuous improvement based on user input

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on creating a systematic process for continuously improving the DCP based on user feedback. It includes implementing feedback collection tools, establishing analysis procedures, and creating improvement prioritization processes.

Target / Deliverables

Operational feedback loop system with improvement tracking dashboard.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.11

3.3 Communications

Establish regular communication channels (newsletters, webinars) for updates

Phase 2 (2026-2027):

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity involves setting up ongoing communication channels to keep stakeholders updated about DCP developments. It includes creating newsletter templates, planning webinar series, and developing content creation workflows.

Target / Deliverables

Regular communication channels with content calendars are established.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.12

3.3 Communications

Plan and execute series of workshops for key stakeholder groups

Phase 2 (2026-2027)

Start Date: 2027-01-01

End Date: 2028-01-01

Duration: 12 months

Decription

This activity focuses on organizing targeted workshops for different stakeholder groups to deepen their understanding and engagement with the DCP. It includes developing workshop curricula, preparing materials, and coordinating logistics.

Target / Deliverables

Workshop series with learning outcome assessments.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.13

3.3 Communications

Launch international knowledge-sharing initiatives

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2028-07-01

Duration: 6 months

Decription

This activity involves initiating programs to share knowledge about the DCP internationally. It includes identifying international partners, developing knowledge exchange protocols, and organizing international events.

Target / Deliverables

International knowledge-sharing initiatives with partner agreements.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.14

3.3 Communications

Develop case studies and best practices documentation

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on creating in-depth case studies and documenting best practices related to DCP implementation and use. It includes conducting research, interviewing stakeholders, and creating comprehensive reports.

Target / Deliverables

Collection of detailed case studies and best practices documentation.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.15

3.3 Communications

Develop comprehensive digital marketing strategy for global promotion of DCP

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity involves creating a digital marketing strategy to promote the DCP globally. It includes developing online content strategies, planning social media campaigns, and implementing SEO tactics.

Target / Deliverables

Comprehensive digital marketing strategy with campaign plans.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.16

3.3 Communications

Design immersive demonstration environments for showcasing DCP capabilities

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on creating interactive environments to demonstrate DCP capabilities. It includes developing virtual reality experiences, creating interactive web demos, and setting up physical demonstration spaces.

Target / Deliverables

Immersive demonstration environments for DCP capabilities.

Responsible party

Activity type: Communication and stakeholder mar

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.17

3.3 Communications

Implement advanced user feedback and co-creation platforms

Phase 3 (2028-2030)

Start Date: 2029-01-01

End Date: 2030-04-30

Duration: 15 months

Decription

This activity involves developing sophisticated platforms for gathering user feedback and facilitating co-creation of DCP features. It includes implementing idea management systems, creating user testing environments, and developing collaborative design tools.

Target / Deliverables

Advanced user feedback and co-creation platform.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.18

3.3 Communications

Host international conferences on digital transformation in construction

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on organizing international conferences to discuss digital transformation in the construction industry, with the DCP as a key topic. It includes planning conference programs, inviting speakers, and managing event logistics.

Target / Deliverables

International conferences with proceedings and impact reports.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.19

3.3 Communications

Create online community platform for DCP users and developers

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2029-01-01

Duration: 12 months

Decription

This activity involves developing an online platform to foster a community around the DCP. It includes creating discussion forums, implementing knowledge sharing tools, and developing collaboration features.

Target / Deliverables

Online community platform for DCP users and developers.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.20

3.3 Communications

Establish regular industry-wide conferences and events

Phase 3 (2028-2030)

Start Date: 2028-01-01

End Date: 2030-04-30

Duration: 27 months

Decription

This activity focuses on organizing recurring industry events centered around the DCP and digital construction. It includes developing event concepts, creating sponsorship programs, and establishing an event management team.

Target / Deliverables

Regular industry-wide conference series with attendance trends.

Responsible party

Activity type: Stakeholder engagement and integra

Scenario: General

CDF Resource: *delivery

Predecessor:

3. Platform Delivery

Activity ID: 3.3.21

3.3 Communications

Develop comprehensive impact assessment and reporting system for NRC DCP

Phase 3 (2028-2030)

Start Date: 2029-07-01

End Date: 2030-04-30

Duration: 9 months

Decription

This activity involves creating a system to assess and report on the impact of the NRC DCP. It includes developing impact metrics, implementing data collection methods, and creating reporting templates.

Target / Deliverables

A comprehensive impact assessment and reporting system for NRC DCP.

Responsible party

Activity type: Reporting

Scenario: General

CDF Resource: *delivery

Predecessor:

Appendix 2 - Automated Rule Checking System Components

Automated Rule Checking process comprising four key stages. The process begins with Rule Interpretation, where written rule bases are translated into computer-implementable formats. This stage involves methods for translating rules by programmers or using predicate logic, defining the ontology of names and properties, and coding rules either in computer code or parametric tables. The next stage, Building Model Preparation, involves extracting and deriving model view data for checking. This includes generating model views to derive implicit properties using enhanced objects, creating new models, and performing performance-based model views and analysis, with an emphasis on the visibility of layout rule parameters.

Following preparation, Rule Execution applies the defined rules to the building model, ensuring syntactic pre-checking of model views and managing view submissions for completeness and version consistency. The final stage, Reporting Checking Results, involves reporting the checking results back to the submitter or checking agency. This stage includes graphical reporting of rule instances and referencing the source rule, completing the feedback loop. Together, these stages provide a comprehensive approach to rule-based model checking, from initial interpretation to final reporting.

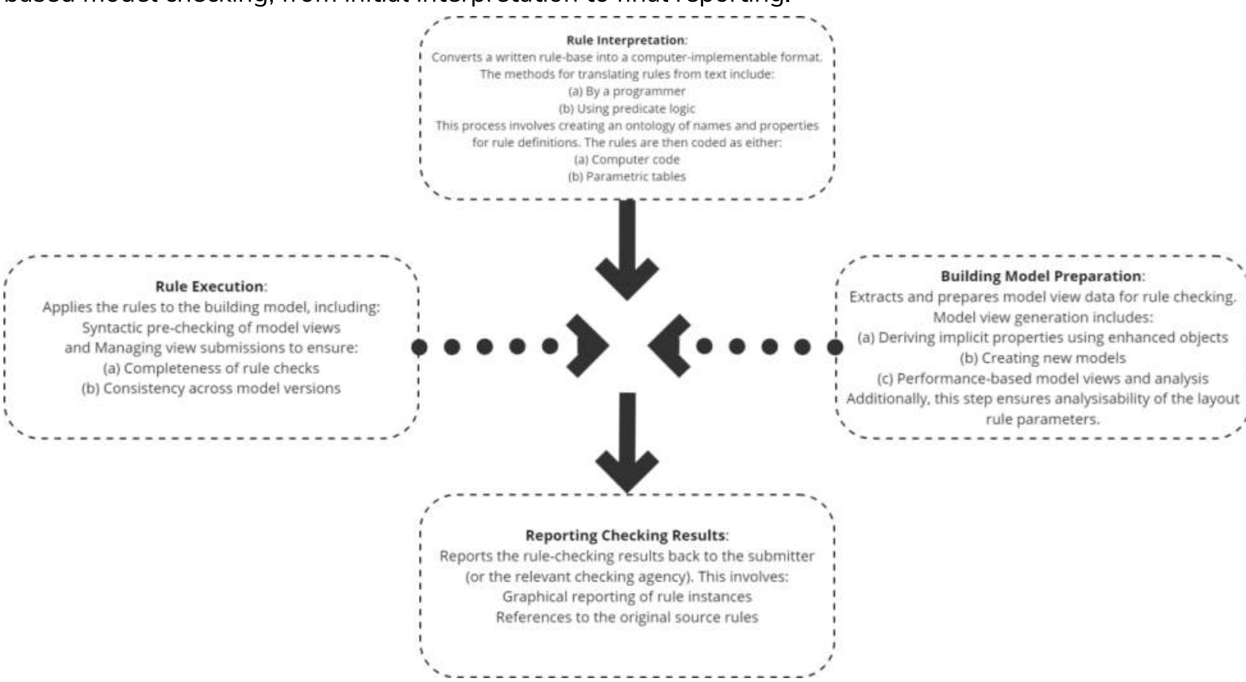

Figure A2.1 33 Automated Rule Checking System Components (Adapted from Eastman, Lee, Jeong, & Lee, 2009)

Rule Interpretation

The process of capturing rules for automated compliance checking of building codes is divided into two main sections: Manual Rule Capture Process and Semi-Automated/Automated Rule Capture Process. The Manual Rule Capture Process involves four key stages: Rule Classification, where rules are defined by format and function; Rule Representation, involving methods such as graphical and mathematical models; Rule Standardization, using specific languages or models for standardizing rules; and Rule Implementation, ensuring consistent integration of rules into the system.

In contrast, the Semi-Automated/Automated Rule Capture Process leverages automation to enhance efficiency and accuracy. This process includes Rule Classification and Formalization, which employs text classification methods and knowledge-based systems for automatic rule processing; Rule Conversion and Verification, using specialized tools and models for accurate rule conversion; and Rule Integration and Application, enabling seamless integration of rules into automated compliance systems.

Process type	Stage	Details
Manual Rule Capture Process	Rule Classification	Defines rule format (text, table) and identifies rule functions (logic, arithmetic)
	Rule Representation	Methods for representing rules, including graphical and mathematical models
	Rule Standardization	Standardizes rules using specific languages or models
	Rule Implementation	Implements rules into the system, ensuring consistency and compliance
Semi-Automated /Automated Rule Capture Process	Rule Classification and Formalization	using text classification methods and knowledge-based systems
	Rule Conversion and Verification	Converts and verifies rules using specific tools and models
	Rule Integration and Application	Integrates rules into the system, enabling automated compliance checking

Figure A2.2 34 Rule interpretation types and processes

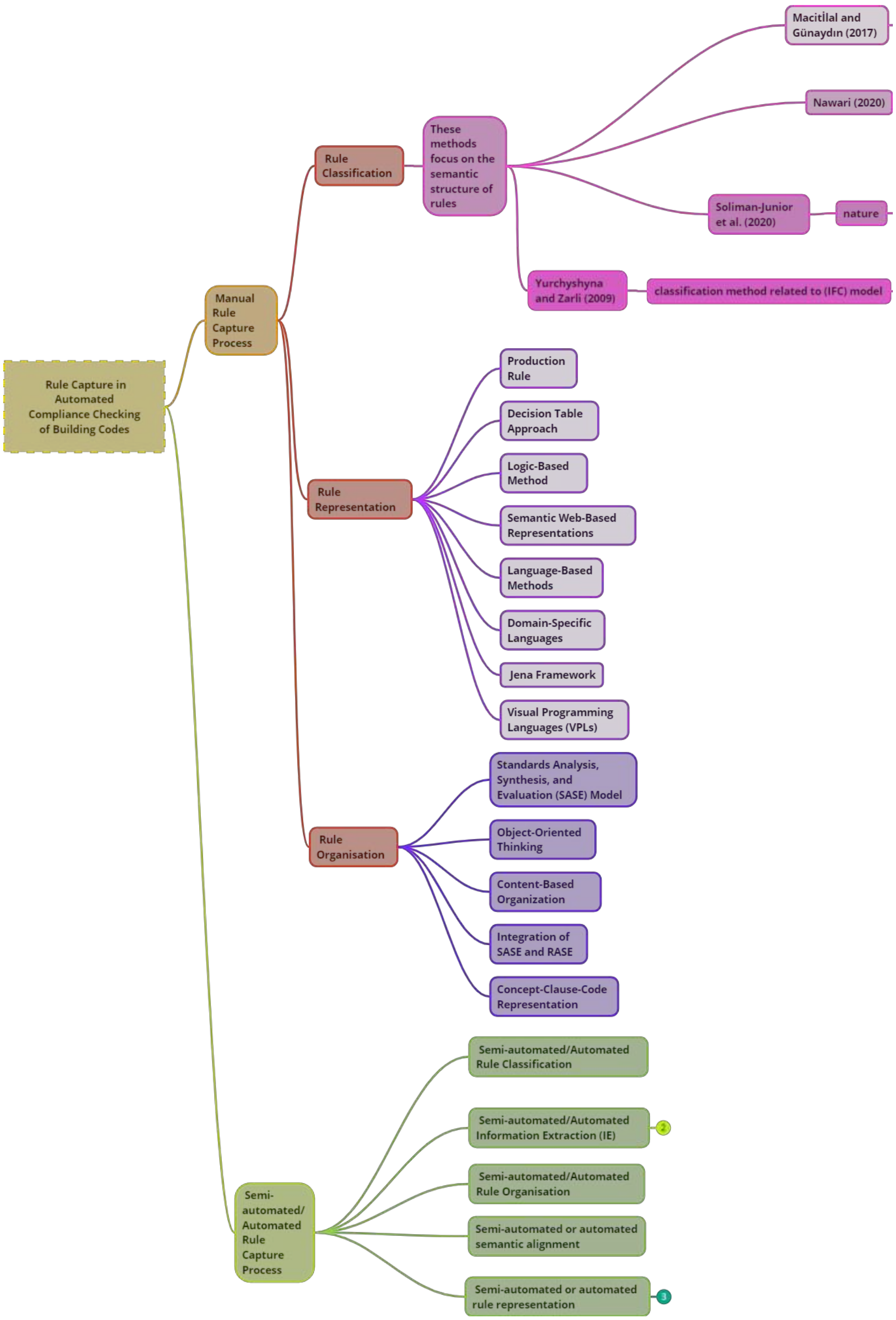

Figure A2.3 35 Rule capture types and processes

Rule Execution: Existing Software or Plug-in Applications

Several software and plug-in applications are currently employed to execute rules and ensure compliance with building regulations. These tools offer various functionalities, from checking 2D drawing compliance to model checking and ensuring accessibility and fire safety standards. The following table lists these applications and their primary functionalities:

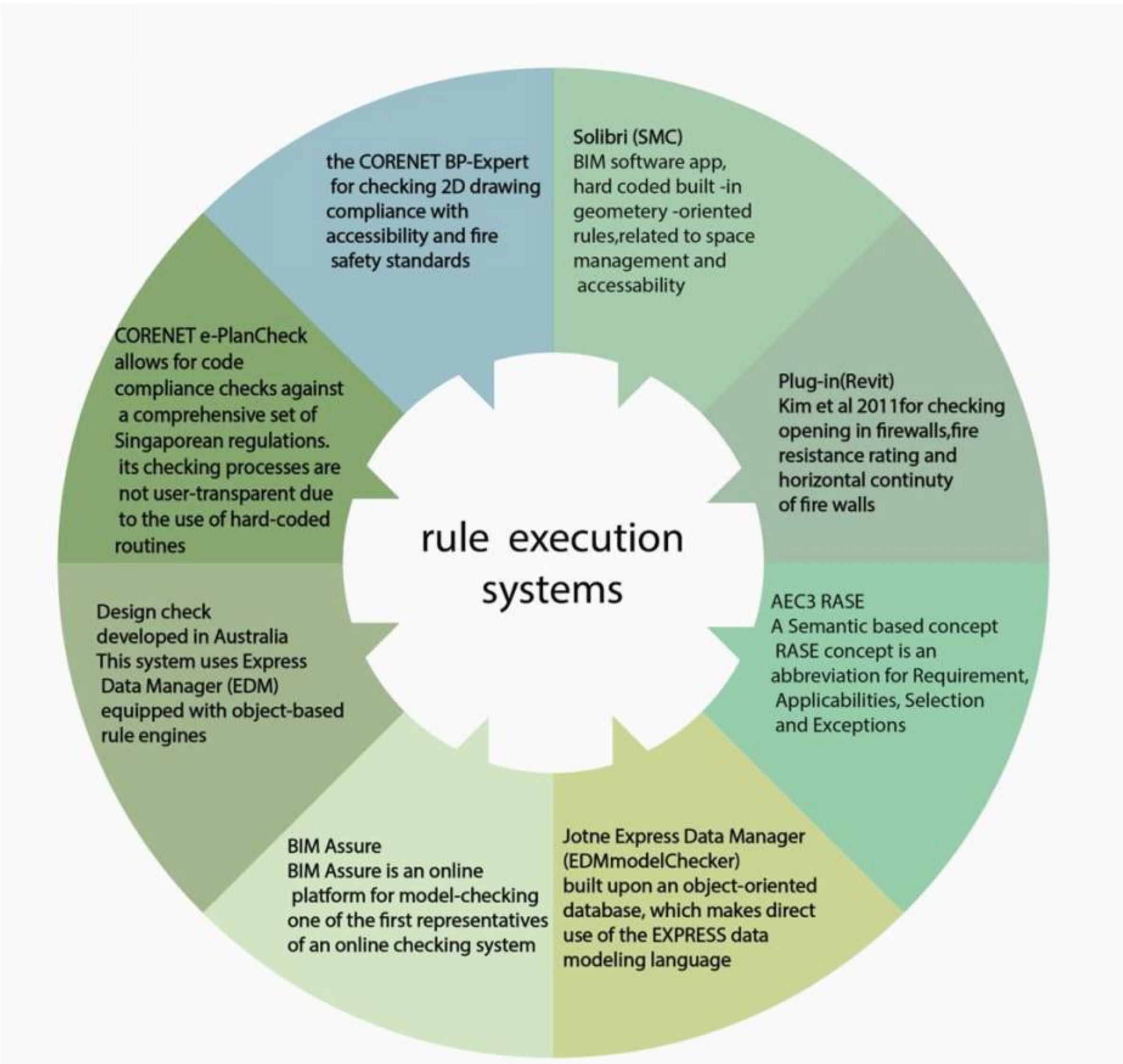

Figure A2.4 36 37 Rule execution: Existing software or plug-in applications

The table below summarizes the various rule interpretation techniques, the countries where they are applied, and the specific regulations involved:

Table A2.115 rule interpretation techniques

Technique/s	Countries	Regulations involved
SMC	U.S.	Occupant circulation rules
SMC	Norway	Building accessibility rules
Autodesk Revit (Plug-in)	U.S.	Fire safety requirements
Object-based approach	Singapore	Clear area in household shelters
Object-based approach	Singapore	Rules in building plans and services
Object-based approach	Australia	Disabled access code
Object-based approach	Turkey	Fire safety requirements
Object-based approach	U.K.	Fire safety requirements for dwelling houses
Object-based & logical approach	U.S.	Fall protection and safety rules
Logical approach	U.S.	Occupant circulation rules
Logical approach	Korea	Building permit requirements
Logical approach	U.S. & Singapore	Hospital visibility, environment and safety, fire safety & accessibility rules
Structured Query Language	Portugal	Domestic water system regulations
Decision table	U.S.	Steel design specifications
Decision table	Canada	Hygrothermal performance of an exterior wall
Ontological approach	France	Construction regulations
Ontological approach & SMC	U.S.	Energy conservation codes
Ontological approach	France	Technical guides of tile roofs
Ontological approach	China	Construction quality inspection and evaluation
RASE	Norway, UAE, U.S.	Accessibility, building habitable spaces, and occupant circulation rules
RASE	U.S.	Sustainability and environmental requirements
RASE & Dialogue Language	Australia	Fire safety requirements
RASE & decision logic	U.K.	Sustainability requirements

Comparison of Automated Code Compliance Checking Systems

Dubai and Singapore are two countries that have developed advanced e-permitting systems. These systems have been studied in detail in this report as exemplary cases for application. Both Singapore and Dubai have developed robust automated code compliance checking systems that reflect their commitment to leveraging technology for urban development and smart city initiatives. While CORENET excels in comprehensive integration and collaboration, Dubai's BPS stands out for its user-friendly approach and significant time-saving benefits. Both systems serve as exemplary models for other cities looking to enhance their regulatory frameworks through digital transformation.

Table A2.2 Comparison of Automated Code Compliance Checking Systems (Dubai vs Singapore)

#	Phases	Elements and Functionalities	Dubai	Singapore (source: bcs.gov.sg)
1	Rule Interpretation	Rule Engine		FORNAX objects provide rules for assessing themselves
2		Predefined Rules	Predefined rules are available for various building types, and custom rules can be created for specific project requirements	Built-in common rules
3		Custom Rules		While the system uses predefined rules, custom rule creation might not be available
4		Code Library		Fornax (C++ object library that derives new data and creates extended views of IFC data) captures higher-level semantics of building components for code checking.
5	Building Model Preparation	Modelling Templates	Bentley Open Building Designer-ArchiCAD BIM-Revit BIM	
6		Modelling and Simulation Tools	The platform itself doesn't offer direct modelling or simulation tools. However, it	

#	Phases	Elements and Functionalities	Dubai	Singapore (source: bcs.gov.sg)
			supports the import of BIM models created using various authoring tools (e.g., Revit, ArchiCAD, etc.).	
7		Accurate and Detailed Model Checker	The platform's automated code compliance checker helps identify and flag potential issues with a BIM model against relevant regulations and standards. While the level of detail in checks can vary depending on the specific rule, the platform aims to provide comprehensive feedback	from CORENET 2.0 utilizes an automated model checker for certain types of submissions.
8		Discipline Specific model input	The platform doesn't explicitly require discipline-specific input, but the BIM models themselves can incorporate discipline-specific information (e.g., structural, architectural, MEP).	The system accepts discipline-specific model input formats like architectural models and structural models
9		Georeferenced information input	IFC format can be converted to a special 3D building GIS data model	
10		(Open) formats acceptance	(.IFC) Required for all building permit submissions where BIM is mandated	"A localized IFC data model is developed based on the IFC standard to address local regulatory needs is termed as IFC-SG"
11	Rule Execution	Algorithmic Logic	The platform's rule engine leverages algorithmic logic to assess BIM models for compliance with regulations and standards.	The platform's rule engine leverages algorithmic logic to assess BIM models for compliance with regulations and standards.

#	Phases	Elements and Functionalities	Dubai	Singapore (source: bcs.gov.sg)
			The specific algorithms used are not publicly available.	The specific algorithms used are not publicly available.
12		pre-check possibility	Available for consultant and permit engineers	Enables self-checking by consultants prior to submission
13		API Integration	The platform doesn't currently have a public API for integration with other systems	The system provides API integration for potential future development
14		Rule-based Engine	Specification is not publicly available	
15		Automated Checks	The platform automates various checks based on predefined rules, including code compliance, information completeness, and file format validity	CORENET e-Plan Check using artificial intelligence (AI) and feature-based building information modelling (BIM) technologies.
16		Iterative Analysis	The platform's workflow allows for iterative analysis, where users can address identified issues in their BIM models and resubmit them for review	The system allows for revisions and resubmissions
17	Reporting and Checking Results	Visualization and Feedback	The platform provides visualizations of identified issues within the BIM model, along with textual descriptions and references to relevant regulations or standards	Visual representation
18		Documentation and Reporting	The platform generates reports summarizing the results of the automated checks, including identified issues and compliance status	The system generates reports on submitted plans and approvals
19	Other Elements and Functionalities	User Interface	Online-user friendly	A web-based user interface for submissions and tracking
20		Security	The platform implements security measures to	The system implements security measures to

#	Phases	Elements and Functionalities	Dubai	Singapore (source: bcs.gov.sg)
			protect user data and BIM models. Specific details about these measures are not publicly available.	protect user data and submitted documents
21		Customization	The platform currently offers limited customization options for users	With IFC-SG
22		Integration Capabilities	The platform has limited integration capabilities	
23		Collaboration of agencies	The specific functionalities for collaboration are not yet fully developed	BCA, URA, NParks, LTA, NEA, PUB, SCDF, SLA, HDB, JTC, GovTech.
24		Updates and Maintenance	The platform is under ongoing development, and new features and functionalities are being added regularly	CORENET - CORENET2 - CORENETX

Appendix 3 – Background on the NMCC

This appendix provides background on the National Model Construction Codes. The NMCC were first released in 1941 and were initially available in print. The Codes then moved to desktop publishing in the late 1980s, adopted SGML in 1995, and were first released electronically in 1996 using Dynatext. By 2005, following Dynatext's discontinuation, the Codes were published with the NXT CD tool, and their content was converted from SGML to XML, illustrating the continuous digitalization efforts to improve accessibility and efficiency. Figure A3.1 illustrates the evolution of the NMCC.

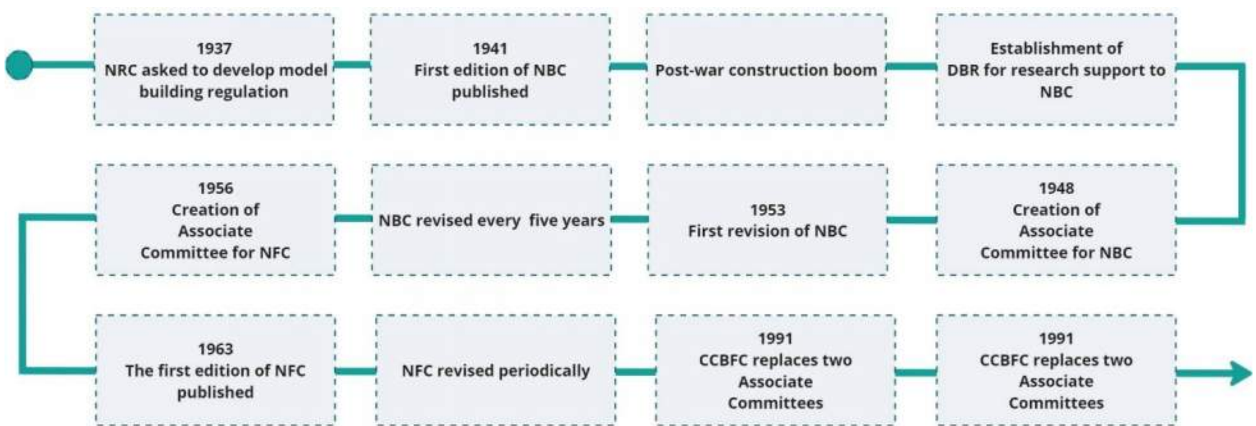

Figure A3.1 Evolution of the NMCC

The Canadian Codes Centre (CCC) under the NRC supports the Canadian Commission on Building and Fire Codes (CCBFC). The CCBFC manages committees and task groups. Building codes are primarily a provincial and territorial responsibility, with the CCBFC working alongside the Provincial/Territorial Policy Advisory Committee on Codes (PTPACC) to facilitate adopting or modifying model building codes across various jurisdictions (Figure A3.2). The roles and responsibilities of stakeholders involved in the building code development and implementation process are identified in figure A3.3.

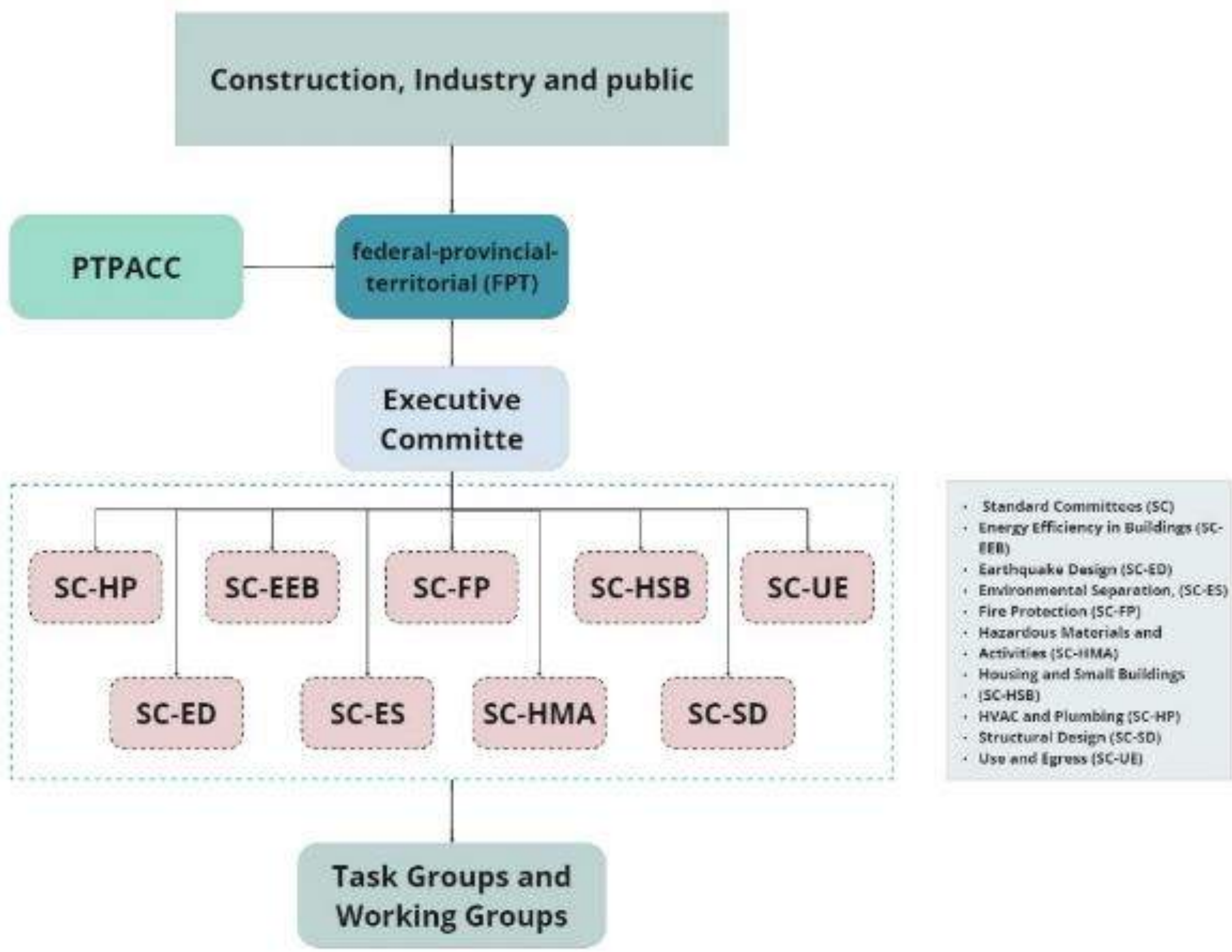

Figure A3.2 Structure of the Canadian Commission on Building and Fire Codes

Several provinces have developed their own construction codes, largely based on the NMCC. For example, British Columbia's building codes are governed by the Building Act, which empowers the province to set the BC Codes. The local governments are responsible for administering and enforcing these provincial building requirements, while also having the authority to govern related matters such as land use and heritage conservation.

The BC building codes are based on the NMCC and are updated every five years to ensure they remain current and effective in addressing the needs of the community and the industry. Local governments review building plans and monitor construction for compliance with the building codes. They hire building officials (building inspectors) who can be qualified to one of three levels:

- Level 1: One- and two-family dwellings (under Part 9).

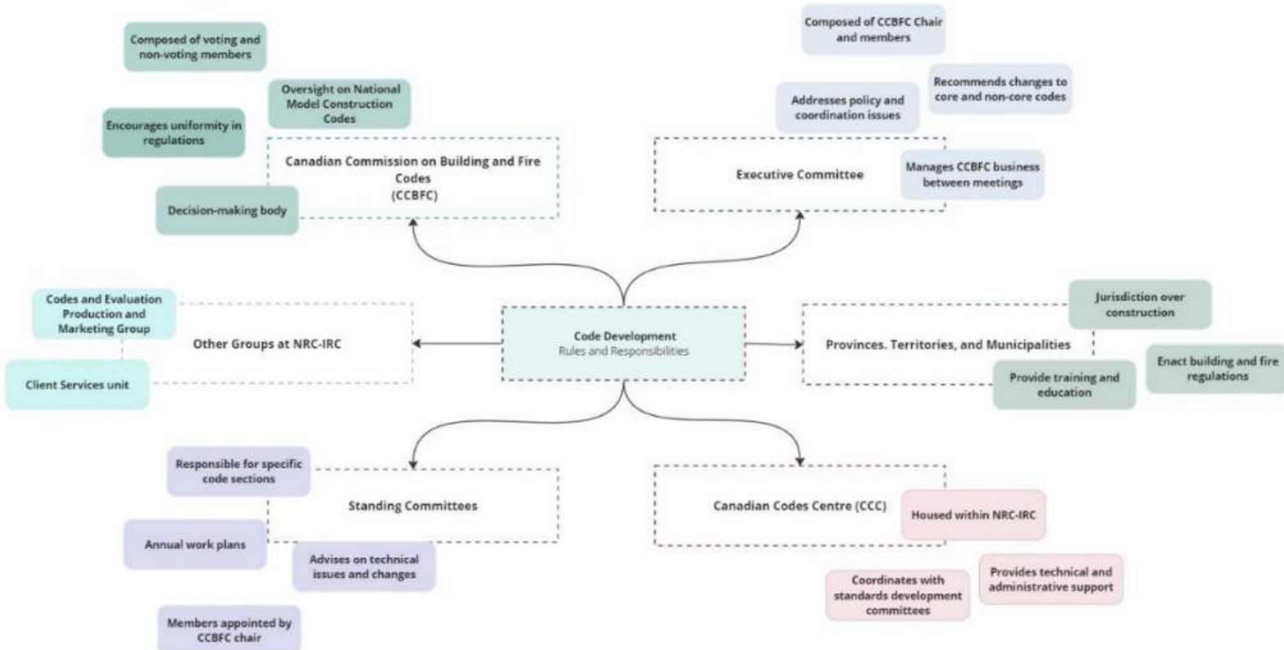

Figure A3.3 Code development - Roles & responsibilities

- Level 2: Other buildings regulated under Part 9.
- Level 3: Larger or more complex buildings regulated under Part 3.

If there are disputes regarding compliance, the Building Code Appeal Board is available to resolve these disputes. Compliance to the building code can be achieved by meeting the prescribed requirements or by proposing alternative solutions. This structured approach ensures that British Columbia's building codes are effectively implemented and enforced.

Characteristics of the NMCC

- Consistency Across Jurisdictions

National model codes serve to promote consistency among provincial and territorial building codes. They act as templates, helping to ensure uniformity in construction standards across different regions.

- Legal Status

Model codes themselves do not carry legal authority. They become enforceable only when adopted by a relevant government authority.

- Local Applicability

Individuals involved in building design or construction should consult the relevant provincial or territorial authorities to determine the applicable building code.

- Regular Updates

The National Building Code is updated periodically, typically every five years, to incorporate advancements in building technology, materials, and practices. The most recent update was in 2020, with the next scheduled for 2025.

- Municipal Implementation

At the municipal level, the building codes adopted by the provincial or territorial authorities (often based on the national model codes) are enforced.

- Core Codes

New editions of the National Model Codes address only those issues that have been agreed upon by all provinces and territories. Issues beyond the scope of these core codes are managed through separate documents published by the respective province or territory.

- Provincial/Territorial Participation

Provinces and territories now could review and influence proposed changes to the National Model Construction Codes at every stage of the development cycle. Their feedback is considered by the Canadian Commission on Building and Fire Codes.

Structure of the model codes

The model codes are systematically organized into three main divisions to ensure comprehensive coverage and clarity.

Division A delineates the scope of the code and specifies the objectives, outlining the necessary conditions for compliance.

Division B provides acceptable solutions and includes objectives related to health and safety, functional statements, and intent statements that articulate the specific purposes and functions addressed by the requirements.

Division C encompasses the administrative provisions required for the effective implementation and enforcement of the code. This structured approach facilitates a clear understanding and application of the model codes.

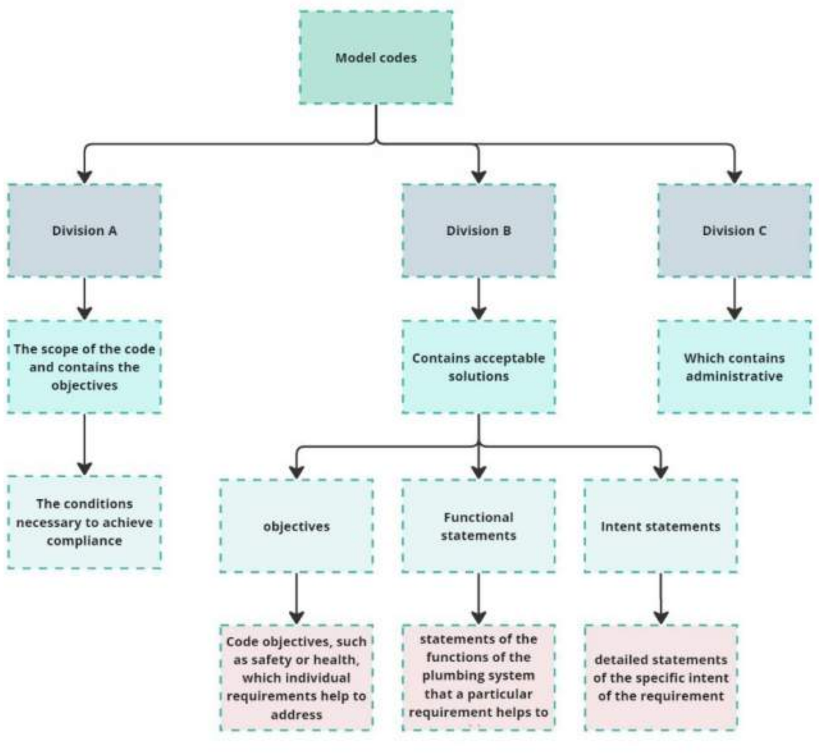

Figure A3.4 Structure of the model codes

Numbering System

The current structure of the codes is to be considered in the digitalization of its content. As described in the front matter of the building codes: "A consistent numbering system has been used throughout the National Model Codes. The first number indicates the Part of the Code; the second, the Section in the Part; the third, the Subsection; and the fourth, the Article in the Subsection. The detailed provisions are found at the Sentence level (indicated by numbers in brackets), and Sentences may be broken down into Clauses and Subclauses. This structure is illustrated as follows:"

Table A3.1 Numbering System of the National Model Codes

3	Part
3.5.	Section
3.5.2.	Subsection
3.5.2.1.	Article
3.5.2.1.(2)	Sentence
3.5.2.1.(2)(a)	Clause
3.5.2.1.(2)(a)(i)	Subclause

Table A3.2 Important aspects of NMC (Taken from (National Research Council of Canada, 2019))

Aspect	Recommendation Source	Details
Textual Improvement	Construction Specifications Canada (CSC)	For the textual improvement of construction specifications, including their language and style.
Numbering and Naming (Prescriptive Specifications)	CSC / CSI MasterFormat MC	For the numbering and naming of prescriptive specification divisions and sections.
Numbering and Naming (Performance Specifications)	CSC / CSI UniFormat MC	For the numbering and naming of performance specifications group of elements and levels.
Organization of Information (Prescriptive Sections)	CSC / CSI SectionFormat MC	Organizes information within prescriptive sections according to a structure of three parts: PART 1: GENERAL, PART 2: PRODUCTS, PART 3: EXECUTION. Each part is further divided into consistently named articles and paragraphs.
Organization of Information (Performance Sections)	Construction Specification Institute (CSI) PPDFormat MC	For part of the organization of information within performance sections.

Appendix 4 – Common Data Framework: Existing Resources

Appendix 4 identifies several existing resources that can constitute the CDF. This list is not exhaustive and shall be updated as work progresses on the DCP. Work aimed at identifying such resources has been undertaken in past research projects. The list below builds on this past research, namely the following publications:

- (Mecharnia et al., 2023) & (Rasmussen, M.H. et al., 2022)
- (Partridge et al., 2020) & https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/
- (Poirier et al. 2022)

Semantic resources

Table A4.1 Semantic resources

CDF Category	Name	Description	Source	URL
Classification	CB-NL	The CB-NL (Concept Library for the Built Environment) delivers an unambiguous description of built environment concepts.	(Mecharnia et al., 2023)	https://www.taylorfrancis.com/chapters/edit/10.1201/9781315375175-79/dutch-concept-library-cb-nl-support-bim-life-cycle-bakker-stolwijk
Classification	CCIC	Defines a construction classification system.	(Mecharnia et al., 2023)	https://cci-collaboration.org/

CDF Category	Name	Description	Source	URL
Classification	ECLASS	eClass is the global reference data standard for the classification and unambiguous description of products and services.	(Mecharnia et al., 2023)	https://eclass.eu/en/
Classification	ETIM	European Technical Information Model is an open standard for the unambiguous grouping and specification of products in the technical sector through a uniform classification system.	(Mecharnia et al., 2023)	https://www.etim-international.com/
Classification	ISO 12006-1	This standard identifies a set of recommended classification table titles for a range of information object classes according to particular views, e.g., by form or function, supported by definitions. It shows how the object classes classified in each table are related, as a series of systems and subsystems, e.g., in a building information model.	(Mecharnia et al., 2023)	https://www.iso.org/standard/61753.html
Classification	NEN 2699	This standard gives a classification of working costs and lifecycle costing of buildings of real estate, that is: areas, buildings with sites. Boats and mobile homes are not included.	(Mecharnia et al., 2023)	https://www.nen.nl/en/nen-2699-2017-nl-230945
Classification	OMNICLASS	Classification System commonly used in North America. It is used for organizing and retrieving information specifically designed for the construction industry.	(Mecharnia et al., 2023)	https://www.csiresources.org/standards/omniclass/standards-omniclass-about
Classification	UNICLASS	UNICLASS - UK Classification Schema for Built Environment Entities: this is a unified classification system for the built environment covering all sectors and roles. Uniclass is a way to organize everything required for built environment assets and provide a logical code for each general item, which can be used by anyone to identify and refer to it.	(Mecharnia et al., 2023)	https://www.thenbs.com/our-tools/uniclass
Classification	UNIFORMAT II	Standard Classification for Building Elements and Related Site work.	(Mecharnia et al., 2023)	https://www.astm.org/e1557-09r20e01.html
Dictionary	ISO 16818	ISO 16818:2008 gives terms and definitions for use in the design of energy-efficient buildings.	(Mecharnia et al., 2023)	https://www.iso.org/standard/41301.html
Dictionary	ISO 18523	ISO 18523-1:2016 specifies the formats to present schedule and condition of building, zone and space usage, which is to be referred to as input data of energy calculations for non-residential buildings.	(Mecharnia et al., 2023)	https://www.iso.org/standard/62765.html

CDF Category	Name	Description	Source	URL
Dictionary	ISO 22496	This document specifies general terminology for windows and pedestrian doors.	(Mecharnia et al., 2023)	https://www.iso.org/standard/73331.html
Dictionary	ISO 22497	This document provides definitions for terms used in documents, drawings, specifications, etc., when referring to the detailed elements of curtain walls.	(Mecharnia et al., 2023)	https://www.iso.org/standard/73332.html
Dictionary	ISO 6707	Buildings and civil engineering works: This document contains the terms and definitions of general concepts to establish a vocabulary applicable to buildings and civil engineering works.	(Mecharnia et al., 2023)	https://www.iso.org/standard/77077.html
Dictionary	ISO 8930	This document establishes the common vocabulary of the principal terms used in the field of reliability of structures.	(Mecharnia et al., 2023)	https://www.iso.org/standard/74452.html
Dictionary	ISO/CD 7615	The proposed standard is the first part of a comprehensive series of international standards related to energy performance of underfloor air distribution systems. This standard shall stipulate the definition, terminology, technical specification and symbols related to underfloor air distribution systems.	(Mecharnia et al., 2023)	https://www.iso.org/standard/82858.html
Dictionary	ISO/FDIS 17607	Determines the general requirements and vocabulary for structural steelwork.	(Mecharnia et al., 2023)	https://www.iso.org/standard/77280.html
Dictionary	ISO/TR 22845	This document provides an index of typical existing information on concept, disaster risk and countermeasure for resilience of buildings and civil engineering works.	(Mecharnia et al., 2023)	https://www.iso.org/standard/74037.html
Dictionary	ISO 16818	ISO 16818:2008 gives terms and definitions for use in the design of energy-efficient buildings.	(Mecharnia et al., 2023)	https://www.iso.org/standard/41301.html
Dictionary	ISO 18523	ISO 18523-1:2016 specifies the formats to present schedule and condition of building, zone and space usage, which is to be referred to as input data of energy calculations for non-residential buildings.	(Mecharnia et al., 2023)	https://www.iso.org/standard/62765.html
Ontology	AEC3PO	"The primary goal of AEC3PO is to facilitate automated rule checking within permitting and compliance processes."	(Mecharnia et al., 2023)	https://github.com/Accord-Project/aec3po
Ontology	BAO	"The Building Assessment Ontology is a concise ontology, developed to semantically describe standards, building codes, certification schemes and regulations in the AEC industry. Its aim is to make the integration of such	(Mecharnia et al., 2023)	https://alexdonkers.github.io/bao/

CDF Category	Name	Description	Source	URL
		schemes with the actual building easier, to automate the performance evaluation of buildings."		
Ontology	BEO	The Building Element Ontology provides an ontology based on the IfcBuildingElement subtree in the IFC specification, containing a taxonomy of classes that allow defining common building elements.	(Mecharnia et al., 2023)	https://pi.pauwel.be/voc/buildingelement/index-en.html
Ontology	BFO	The Basic Formal Ontology (BFO) [...] consists of a series of sub-ontologies at different levels of granularity. The ontologies are divided into two varieties: relating to continuant entities such as three-dimensional enduring objects, and occurrent entities (primarily) processes conceived as unfolding in successive phases through time. BFO thus incorporates both three-dimensionalist and four-dimensionalist perspectives on reality within a single framework. Interrelations are defined between the two types of ontologies in a way which gives BFO the facility to deal with both static/spatial and dynamic/temporal features of reality.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/
Ontology	BIMERR Annotation Objects Ontology	The Annotation Objects ontology aims to represent the annotations produced during the development of a building renovation project. These annotations serve to inform about issues or missing information that could be relevant for the project, such as indicating that a building element is missing in the BIM model.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/def/annotation-objects/
Ontology	BIMERR Building Ontology	This ontology aims to model building data for the BIMERR project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR Information Objects Ontology	This ontology aims to model the files and documents attached to building elements.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR Material Properties Ontology	This ontology aims to model the properties needed to describe building elements for the BIMERR project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/

CDF Category	Name	Description	Source	URL
Ontology	BIMERR Metadata Ontology	This ontology defines annotation properties to support the ontology to data model transformation.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR Occupancy Profile ontology	This ontology aims to model occupants' behaviour inside buildings for the BIMERR project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR Renovation Process Ontology	This ontology aims to model the construction processes in a building renovation project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR Sensor Data Ontology	This ontology aims to model data from sensors located inside buildings for the BIMERR project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR Weather Ontology	This ontology aims to model weather data for the BIMERR project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BIMERR KPI Ontology	The Key Performance Indicator ontology aims to model Key Performance Indicator information related to building renovation works for the BIMERR project.	(Mecharnia et al., 2023)	https://bimerr.iot.linkeddata.es/
Ontology	BONSAI	A core ontology developed specifically to capture the data relevant for lifecycle sustainability assessment.		https://doi.org/10.1111/jiec.13220
Ontology	BORO	Business Objects Reference Ontology is an upper ontology designed for developing ontological or semantic models for large complex operational applications that consists of a top ontology as well as a process for constructing the ontology. It is built upon a series of clear metaphysical choices to provide a solid (metaphysical) foundation. A key choice was for an extensional (and hence, four-dimensional) ontology which provides it a simple criterion of identity.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/

CDF Category	Name	Description	Source	URL
Ontology	BOT	The Building Topology Ontology is a minimal ontology for describing the core topological concepts of a building.	(Mecharnia et al., 2023)	https://w3c-lbd-cg.github.io/bot/
Ontology	BPO	The Building Product Ontology defines concepts to describe (building) products in a schematic way. It provides methods to describe assembly structures and component interconnections and attach properties to any component without restricting their types, as is often the case in template driven product descriptions.	(Mecharnia et al., 2023)	https://annawagner.github.io/bpo/
Ontology	Brick	Brick contains a semantic description of the physical, logical and virtual assets in buildings and the relationships between them	(Mecharnia et al., 2023)	https://brickschema.org/
Ontology	BCAO	Building Circularity Assessment Ontology is proposed to structure the scattered heterogenous manufacturer product data needed for the circulation assessment.	(Mecharnia et al., 2023)	https://itc.scix.net/pdfs/w78-2021-paper-081.pdf
Ontology	Building Regulation Ontology	Represents the knowledge of building regulations. It defines generic concepts and relationships. Then, the constraints in building regulations can be modelled into OWL axioms and SPARQL rules.	(Mecharnia et al., 2023)	https://accordproject.eu/wp-content/uploads/2023/09/ACCORD_D2.1_Technical_Report_Existing_Models.pdf
Ontology	CEON	The Circular Economy Ontology Network (CEON) provides a shared vocabulary for representing information about circular economies in the form of a network of ontology modules.		https://liusemweb.github.io/CEON/
Ontology	CIDOC	The CIDOC Conceptual Reference Model (CRM) is a theoretical and practical tool for information integration in the field of cultural heritage.	(Partridge et al., 2020)	https://www.cidoc-crm.org/
Ontology	Code Ontology	The code ontology designed primarily for code compliance checking is used to describe regulatory information. It is developed based on the regulatory documents for providing the semantics of the compliance checking domains.	(Mecharnia et al., 2023)	https://accordproject.eu/wp-content/uploads/2023/09/ACCORD_D2.1_Technical_Report_Existing_Models.pdf
Ontology	COGITO	Set of ontologies aiming at modelling processes, facilities, resources, quality, safety, IoT and Digital Twin Thing in the construction domain. v		https://cogito.iot.linkeddata.es/
Ontology	CoMOn	Compliance Management Ontology is a shared conceptualization for research and practice in compliance management.	(Mecharnia et al., 2023)	https://doi.org/10.1007/s10796-016-9631-4

CDF Category	Name	Description	Source	URL
Ontology	COSMO	Common Semantic Model (COSMO) is conceived as being made up of a lattice of ontologies which will serve as a set of basic logically specified concepts	(Partridge et al., 2020)	http://ontolog.cim3.net/wiki/COSMO.html
Ontology	CQIE Ontology	Construction Quality Inspection and Evaluation (CQIE) Ontology serves as a meta model, defining the generic terms and relations related to the construction quality compliance checking. It allows modelling regulations in OWL axioms and SWRL rules for construction quality inspection and evaluation.	(Mecharnia et al., 2023)	https://doi.org/10.1016/j.autcon.2012.06.006
Ontology	CTO: Construction Tasks Ontology	The Construction Tasks Ontology (CTO) describes tasks operating on construction elements, spatial zones and/or damages.		https://lov.linkeddata.es/dataset/lov/vocabs/cto
Ontology	Cyc	"Artificial intelligence project that aims to assemble a comprehensive ontology and knowledge base that spans the basic concepts and rules about how the world works"	(Partridge et al., 2020)	https://dbpedia.org/page/Cyc
Ontology	DBO	The Digital Buildings ontology (DBO) is used by Google to represent structured information about buildings and building installed equipment.	(Mecharnia et al., 2023)	https://github.com/google/digitalbuildings
Ontology	DC	Dublin Core (DC) is a light-weight RDFS vocabulary for describing generic metadata.	(Partridge et al., 2020)	https://www.dublincore.org/
Ontology	DCagents	Digital Construction Agents ontology defines the concepts for different kinds of agents relevant to construction and renovation of buildings, their roles, and capabilities. Agents include individual persons and organizations such as trade crews and companies. Agents can either be actors (agents performing activities) and stakeholders (agents that have a stake on the activities or their results).	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Agents/v/0.3/index.html
Ontology	DCAT	Data Catalog Vocabulary (DCAT) is an RDF vocabulary designed to facilitate interoperability between data catalogues published on the Web.	(Mecharnia et al., 2023)	https://www.w3.org/TR/vocab-dcat-3/
Ontology	DCcontexts	Context ontology provides the basic representation mechanisms for multi-context information in construction and renovation projects	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Contexts/latest/

CDF Category	Name	Description	Source	URL
Ontology	DCenergy	An ontology for energy systems and energy efficiency in the construction and renovation domain	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/v/0.5/
Ontology	DCentities	Digital Construction Entities Ontology defines the basic classes and properties needed for the representation of construction and renovation projects. Examples are building object, location, material batch, equipment, agent, information content entity, activity and related time concepts. The ontology is based on BFO.	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Entities/v/0.5/
Ontology	DCinformation	Digital Construction Information ontology defines the representation of information content entities in construction and renovation, including models, plans, scenarios, messages, issues, videos and point clouds. The focus is on identifiable information contents (such as the first version of the architectural model of a project), not on the particular information carries (such as a hard disk, cloud storage, paper print).	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Information/v/0.5/
Ontology	DClifecycle	An ontology to represent the enhancement of building data throughout the construction lifecycle stages	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Lifecycle/v/0.5/
Ontology	DCmaterials	The Material Ontology defining the main concepts of building material, type and its properties.	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Materials/v/0.5/
Ontology	DCoccupancy	Digital Construction Occupancy ontology represents those aspects of construction and renovation projects that concern the comfort, safety and health of occupants, including visual and thermal comfort, indoor air quality and building acoustics, as well as related sensor observations.	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Occupancy/v/0.5/
Ontology	DCprocesses	Process ontology for digital construction	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Processes/latest/
Ontology	DCvariables	The objectified property representation is orthogonal to the other definitions in the ontologies: any property can be objectified and consequently be subject to constraints.	(Mecharnia et al., 2023)	https://digitalconstruction.github.io/Variables/latest/
Ontology	DFS Ontology	The Design for Safety (DFS) ontology is developed based on Natural Language Processing (NLP) for ACC using BIM. It is designed for the Chinese safety regulations.	(Mecharnia et al., 2023)	https://www.mdpi.com/2075-5309/12/6/780

CDF Category	Name	Description	Source	URL
Ontology	Digital Twin Construction Ontology	The Digital Twin Construction Ontology enables representing the most important concepts that are relevant for a digital twin of a construction site.		https://dtc-ontology.cms.ed.tum.de/ontology/index.html
Ontology	DOCK	Domain Ontology for Construction Knowledge categorizes construction knowledge across three main dimensions: concept, modality, and context.	(Mecharnia et al., 2023)	https://doi.org/10.1061/(ASCE)CO.1943-7862.0000646
Ontology	DogOnt	The DogOnt ontology aims at offering a uniform, extensible model for all devices being part of a “local” Internet of Things inside a smart environment.		https://iot-ontologies.github.io/dogont/#:~:text=The%20DogOnt%20ontology%20aims%20at,level%20idiosyncrasies%20and%20communication%20issues.
Ontology	DOLCE	Descriptive Ontology for Linguistic and Cognitive Engineering (DOLCE) is a foundational ontology designed in 2002 in the context of the WonderWeb EU project, developed by Nicola Guarino and his associates at the Laboratory for Applied Ontology (LOA)	(Partridge et al., 2020)	https://www.o4.cms2web.com/kg/TAoKE/Ontologies/DOLCE/index.html
Ontology	EMMO	The EMMO top level is the group of fundamental axioms that constitute the philosophical foundation of the EMMO. Adopting a physicalistic/nominalistic perspective, the EMMO defines real world objects as 4D objects that are always extended in space and time (i.e., real-world objects cannot be spaceless nor timeless). For this reason, abstract objects, i.e., objects that do not extend in space and time, are forbidden in the EMMO. It has been instigated by materials science and provides the connection between the physical world, the experimental world (material characterization) and the simulation world (materials modelling).	(Partridge et al., 2020)	https://emmo-repo.github.io/versions/1.0.0-beta/emmo.html#:~:text=The%20EMMO%20top%20level%20is,cannot%20be%20spaceless%20nor%20timeless).
Ontology	ERA	Vocabulary defined by the European Union Agency for Railways to describe the concepts and relationships related to the European railway infrastructure and the vehicles authorized to operate over it.		https://op.europa.eu/en/web/eu-vocabularies/dataset/-/resource?uri=http://publications.europa.eu/resource/dataset/era-

CDF Category	Name	Description	Source	URL
				vocabulary#:~:text=ERA%20vocabulary%20is%20an%20ontology,authorized%20to%20operate%20over%20it.
Ontology	EULYNX	The EULYNX DataPrep model has been designed to define the format that Infrastructure Managers and suppliers/engineering companies will use to exchange information about signalling engineering and configuration data.		https://eulynx.eu/2023/12/15/eulynx-dataprep-the-information-model-for-signalling-engineering/
Ontology	FIBO	The Financial Industry Business Ontology (FIBO) defines the sets of things that are of interest in financial business applications and the ways that those things can relate to one another.	(Partridge et al., 2020)	https://edmcouncil.org/financial-industry-business-ontology/
Ontology	FOG	The File Ontology for Geometry formats (FOG) provide geometry schema-specific relations between things (e.g., building objects) and their geometry descriptions. These geometry descriptions can be (1) RDF-based, (2) RDF literals containing embedded geometry of existing geometry formats and (3) RDF literals containing a reference to an external geometry file.	(Mecharnia et al., 2023)	https://mathib.github.io/fog-ontology/
Ontology	FrameNet	FrameNet project is building a lexical database of English that is both human- and machine-readable, based on annotating examples of how words are used in actual texts.	(Partridge et al., 2020)	https://bids.github.io/TextXD/
Ontology	GFO	Realistic ontology integrating processes and objects. It attempts to include many aspects of recent philosophy, which is reflected both in its taxonomic tree and its axiomatizations.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/
Ontology	gist	gist is developed and supported by Semantic Arts. gist (not an acronym – it means to get the essence of) is a “minimalist upper ontology.” gist is targeted at enterprise information systems, although it has been applied to healthcare delivery applications.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/
Ontology	Household ontology	The Household ontology defines the classes: Household, Family, and DwellingUnit. These definitions serve as a basis which may be extended for more specific applications such as a surveys and simulations.		https://enterpriseintegrationlab.github.io/icity/Household/doc/index-en.html

CDF Category	Name	Description	Source	URL
Ontology	HQDM	The High-Quality Data Models (HQDM) Framework is a 4-dimensionality top-level ontology with extensional identity criteria that aims to support large-scale data integration. As such it aims to ensure there is consistency among data created using the framework. The HQDM Framework is based on work developing and using ISO 15926 and lessons learnt from BORO, which influenced ISO 19526.	(Partridge et al., 2020)	https://github.com/gchq/HQDM
Ontology	iCity Ontology	iCity ontology to define the urban system and its behaviour; its population, land use, transportation infrastructure, and the travel that occurs within it		https://enterpriseintegrationlab.github.io/icity/UrbanSystem/doc/index-en.html
Ontology	IC-PRO-Onto	Infrastructure and Construction PROcess Ontology is proposed to offer a conceptualization and formal representation of domain process knowledge.	(Mecharnia et al., 2023)	https://doi.org/10.1061/(ASCE)CO.1943-7862.0000178
Ontology	IDEAS	The upper ontology developed by the IDEAS Group is higher order, extensional and 4D. It was developed using the BORO Method. The IDEAS ontology is not intended for reasoning and inference purposes; its purpose is to be a precise model of business.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/
Ontology	IEC 62541	OPC Unified Architecture (OPC UA) is a machine-to-machine communication protocol for industrial automation developed by the OPC Foundation.	(Partridge et al., 2020)	https://webstore.iec.ch/en/publication/61114
Ontology	IEC 63088	IEC PAS 63088:2017(E) describes a reference architecture model in the form of a cubic layer model, which shows technical objects (assets) in the form of layers, and allows them to be described, tracked over their entire lifetime (or "vita") and assigned to technical and/or organizational hierarchies. It also describes the structure and function of Industry 4.0 components as essential parts of the virtual representation of assets.	(Partridge et al., 2020)	https://webstore.iec.ch/en/publication/30082
Ontology	ifcOWL	ifcOWL provides a Web Ontology Language (OWL) representation of the IFC schema.	(Mecharnia et al., 2023)	https://technical.buildingsmart.org/standards/ifc/ifc-formats/ifcowl/
Ontology	ifcWOD	The IFC Web of Data ontology formally extends the ifcOWL ontology.	(Mecharnia et al., 2023)	https://itc.scix.net/pdfs/w78-2015-paper-018.pdf

CDF Category	Name	Description	Source	URL
Ontology	ISO 17800:2017	The Facility Smart Grid Information Model (FSGIM) standard is one part of a larger ecosystem of standards that support the development and implementation of a smart electric grid. The FSGIM uses Unified Modelling Language to define key concepts that must map between electricity providers and electricity consumers. (ISO 17800:2017(en) Facility smart grid information model)	(Mecharnia et al., 2023)	https://www.iso.org/standard/71547.html#:~:text=ISO%2017800%3A2017%20provides%20the,the%20communication%20protocol%20in%20use.
Ontology	KKO	The upper structure of the KBpedia Knowledge Ontology (KKO) is informed by the triadic logic and universal categories of Charles Sanders Peirce. This trichotomy, also the basis for his views on semiosis (or the nature of signs), was in Peirce's view the most primitive or reduced manner by which to understand and categorize things, concepts and ideas.	(Partridge et al., 2020)	https://kbpedia.org/
Ontology	KR Ontology	The KR Ontology is defined in the book Knowledge Representation by John F. Sowa. Its categories have been derived from a synthesis of various sources, but the two major influences are the semiotics of Charles Sanders Peirce and the categories of existence of Alfred North Whitehead. The primitive categories are: Independent, Relative, or Mediating; Physical or Abstract; Continuant or Occurrent.	(Partridge et al., 2020)	https://www.jfsowa.com/ontology/kronto.htm
Ontology	LKIF-core Ontology	Legal Knowledge Interchange Format (LKIF) core ontology is designed to represent basic legal concepts for buildings.	(Mecharnia et al., 2023)	https://github.com/RinkeHoekstra/lkif-core
Ontology	MarineTLO	Is a top-level ontology, generic enough to provide consistent abstractions or specifications of concepts included in all data models or ontologies of marine data sources and provide the necessary properties to make this distributed knowledge base a coherent source of facts relating observational data with the respective spatiotemporal context and categorical (systematic) domain knowledge.	(Partridge et al., 2020)	https://aims.fao.org/news/marinetlo-top-level-ontology-marine-domain
Ontology	MEP	The Distribution Element Ontology provides an ontology based on the IfcDistributionElement subtree in the IFC specification, containing a taxonomy of classes that allow defining common distribution elements (actuators, flow terminals, ...).	(Mecharnia et al., 2023)	https://pi.pauwel.be/voc/distributionelement/index-en.html

CDF Category	Name	Description	Source	URL
Ontology	MIMOSA CCOM	MIMOSA CCOM (Common Conceptual Object Model) serves as an information model for the exchange of asset information. Its core mission is to facilitate standards-based interoperability between systems: providing an XML model to allow systems to electronically exchange data.	(Partridge et al., 2020)	https://www.mimosa.org/mimosa-ccom/
Ontology	OBPA	The Ontology for building permit authorities contains vocabulary for describing organizational structures of building permit authorities.	(Mecharnia et al., 2023)	https://doi.org/10.1016/j.aei.2023.102216
Ontology	OEMA Ontology network	The OEMA ontology network covers different energy domains (i.e., energy performance, infrastructure, weather data, etc.) represented in different existing energy ontologies at the greatest level of detail. The OEMA ontology network also provides a common representation of concepts that belong to different energy domains. The OEMA ontology network is made up of eight interconnected domain ontologies. Each ontology represents one or various energy domains.		https://www.bim4eeb-project.eu/media/doc/BIM4EEB_D3.2_SUITE5_v4.0.pdf
Ontology	OEO	The Open Energy Ontology (OEO) is created as a domain ontology within the field of energy system modelling.		https://openenergyplatform.org/ontology/
Ontology	OMG	The Ontology for Managing Geometry (OMG) is an ontology for attaching geometry descriptions to their corresponding things (e.g., building objects). The OMG is designed to provide three levels of adding the geometry descriptions which can be used and combined flexibly.	(Mecharnia et al., 2023)	https://annawagner.github.io/omg/
Ontology	Ontology Central Repository	The repository contains ontology models for commercial buildings.		https://www.w3.org/wiki/Ontology_repositories
Ontology	OntoRail	Provide ontology-based tools to promote and facilitate convergence and federation between models of the railway's domain.		https://ontorail.org/
Ontology	OpenADR	The Open Advanced Demand Response (OpenADR) was created to standardize, automate, and simplify Demand Response (DR) and Distributed Energy Resources (DER) to enable utilities and aggregators to cost effectively manage growing energy demand & decentralized energy production, and customers to control their energy future	(Mecharnia et al., 2023)	https://www.openadr.org/

CDF Category	Name	Description	Source	URL
Ontology	OPM	The Ontology for Property Management (OPM) is an ontology for describing temporal properties that are subject to changes as the building design evolves.	(Mecharnia et al., 2023)	https://w3c-lbd-cg.github.io/opm/
Ontology	POE Ontology	Post-Occupancy Evaluation Ontology is developed to evaluate the actual building performance against the theoretical design intents after the building has been occupied for some time.	(Mecharnia et al., 2023)	https://doi.org/10.1051/ijmqe/2021019
Ontology	PROTON	Is designed as a lightweight upper-level ontology, serving as a modelling basis for a number of tasks in different domains.	(Partridge et al., 2020)	https://ontotext.com/documents/proton/Proton-Ver3.0B.pdf
Ontology	Railway Code Ontology	Semi-automatic generation of Code Ontology using ifcOWL in compliance checking.	(Mecharnia et al., 2023)	https://doi.org/10.1155/2021/8861625
Ontology	RealEstateCore (REC)	RealEstateCore is a modular ontology, that is, a collection of data schemas that describe concepts and relations that can occur in data that is generated to model buildings and building systems, or that is sourced from such systems.	(Mecharnia et al., 2023)	https://www.realestatecore.io/
Ontology	SAREF	The Smart Applications REFerence ontology (SAREF) is intended to enable interoperability between solutions from different providers and among various activity sectors in the Internet of Things (IoT), thus contributing to the development of the global digital market. It has two extensions: SAREF4ENER for energy and SAREF4BLDG for buildings.	(Mecharnia et al., 2023)	https://saref.etsi.org/core/v3.1.1/
Ontology	SAREF4BLDG	SAREF4BLDG is the SAREF extension for building devices and aims for a more efficient interaction and integration of actors, methods and tools during the different phases of the building lifecycle.	(Mecharnia et al., 2023)	https://saref.etsi.org/saref4bldg/v1.1.2/
Ontology	SEAS	The Smart Energy Aware Systems (SEAS) knowledge model is a key enabler for the semantic interoperability at the basis of SEAS use cases and business models for energy efficiency	(Mecharnia et al., 2023)	https://itea4.org/project/seas.html
Ontology	SEAS (Smart Energy Aware Systems) project	"The ITEA2 Smart Energy-Aware Systems (SEAS) project aimed at designing and developing a global ecosystem of services and smart things collectively capable of ensuring the stability and the energy efficiency of the future energy grid."		https://itea4.org/project/seas.html

CDF Category	Name	Description	Source	URL
Ontology	SENSUS	SENSUS is a 70,000-node terminology taxonomy, as a framework into which additional knowledge can be placed. SENSUS is an extension and reorganization of WordNet.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/
Ontology	SOSA	The Sensor, Observation, Sample, and Actuator ontology provides a standardized vocabulary and data model for describing and sharing information about sensors, observations, samples, and actuators. It aims to address the challenges of integrating and exchanging data from diverse sources, with varying levels of granularity and complexity, by defining a set of common concepts and relationships for describing the components of an IoT system.	(Mecharnia et al., 2023)	https://doi.org/10.48550/arXiv.1805.09979
Ontology	SSN	The Semantic Sensor Network ontology is an ontology for describing sensors and their observations, the involved procedures, the studied features of interest, the samples used to do so, and the observed properties, as well as actuators	(Mecharnia et al., 2023)	https://www.w3.org/TR/vocab-ssn/
Ontology	SUMO	The Suggested Upper Merged Ontology (SUMO) is an upper ontology intended as a foundation ontology for a variety of computer information processing systems. SUMO is organized for interoperability of automated reasoning engines. It is being used for research and applications in search, linguistics and reasoning.	(Partridge et al., 2020)	https://www.ontologyportal.org/
Ontology	ThinkHome	The vision of ThinkHome is to create a comprehensive knowledge base which includes all the different concepts needed to realize energy efficient, intelligent control mechanisms.		https://www.auto.tuwien.ac.at/index.php/research-fields/ontology
Ontology	UFO	Incorporates developments from GFO, DOLCE and the Ontology of Universals underlying OntoClean in a single coherent foundational ontology.	(Partridge et al., 2020)	https://ontouml.readthedocs.io/en/latest/intro/ufo.html
Ontology	UMBEL	Is a logically organized knowledge graph of 34,000 concepts and entity types that can be used in information science for relating information from disparate sources to one another. Since UMBEL is an open-source extract of the OpenCyc knowledge base, it can also take advantage of the reasoning capabilities within Cyc.	(Partridge et al., 2020)	https://digitaltwinhub.co.uk/groups/imf-community/forum/discussions/top-level-ontologies-long-list/

CDF Category	Name	Description	Source	URL
Ontology	WordNet	WordNet® is a large lexical database of English. Nouns, verbs, adjectives and adverbs are grouped into sets of cognitive synonyms (synsets), each expressing a distinct concept.	(Partridge et al., 2020)	https://wordnet.princeton.edu/#:~:text=WordNet%C2%AE%20is%20a%20large,conceptual%2Dsemantic%20and%20lexical%20relations.
Ontology	X2Rail	Advanced signalling and automation system - Completion of activities for enhanced automation systems, train integrity, traffic management, evolution and smart object controllers.		https://projects.shift2rail.org/s2r_ip2_n.aspx?p=X2RAIL-1
Ontology	YAMATO	Yet Another More Advanced Top-level Ontology which has been developed intended to cover three features in Quality description, Representation and Process/Event, respectively, in a better way than existing ontologies. It has been extensively used for developing other, more applied, ontologies.	(Partridge et al., 2020)	https://www.hozo.jp/onto_library/upperOnto.htm

Syntactic resources

Table A4.2 Syntactic resources

CDF Category	Name	Description	Source	URL
Format	BCF	BIM Collaboration Format: File Based Transmission. BCF is a file format allowing BIM applications to communicate model-based issues with each other. BCF is a Building Smart International standard.	(Mecharnia et al., 2023)	https://www.buildingsmart.org/standards/bsi-standards/bim-collaboration-format/
Format	CEN WI 442018	Exchange structure for product data templates and product data based on ifcXML	(Mecharnia et al., 2023)	https://standardsdevelopment.bsigroup.com/projects/9019-03273
Format	CEN WI 442033	Exchange structure for product data templates and product data based on ifcXML - Part 2 Requirements and configurable products	(Mecharnia et al., 2023)	https://standards.iteh.ai/catalog/tc/cen/b0e05107-d6bf-4c1c-b222-54dd974f1a96/cen-tc-442?srsltid=AfmBOooSOUdukp-QTA7qadSiITpT3fueW625YePBZABgLI_ar76w8-AQ
Format	CityJSON	JSON Encoding for CityGML. CityJSON is a JSON-based encoding for storing 3D city models, also called digital maquettes or digital twins (longer explanation)	(Mecharnia et al., 2023)	https://www.cityjson.org/
Format	JSON (ISO/IEC 21778:2017)	JSON defines a small set of structuring rules for the portable representation of structured data. The goal of ISO/IEC 21778:2017 is only to define the syntax of valid JSON texts. Its intent is not to provide any semantics or interpretation of text conforming to that syntax.	(Mecharnia et al., 2023)	https://www.iso.org/standard/71616.html#:~:text=JSON%20defines%20a%20small%20set,text%20conforming%20to%20that%20syntax.
Format	LKIF rules	The Legal Knowledge Interchange Format (LKIF) rule is a semantic web-based language for representing legal knowledge to support modelling of legal	(Mecharnia et al., 2023)	https://ceur-ws.org/Vol-321/paper3.pdf

CDF Category	Name	Description	Source	URL
		domains and to facilitate interchange between legal knowledge-based systems. It is a combination between OWL and SWRL.		
Format	RIF	The Rule Interchange Format (RIF) is a W3C standard for exchanging rules. RIF has several "flavours" addressing different features of rule languages. It can be serialized in RDF or in a more compact format.	(Mecharnia et al., 2023)	https://www.w3.org/TR/rif-overview/
Format	STEP	STEP data format, commonly used to exchange IFC data. It is defined in ISO 10303-242:2014 Industrial automation systems and integration — Product data representation and exchange — Part 242: Application protocol: Managed model-based 3D engineering.	(Mecharnia et al., 2023)	https://www.iso.org/standard/84667.html
Format	XML	Extensible Markup Language.	(Mecharnia et al., 2023)	https://www.w3.org/XML/
Framework	ISO 15926-2	The ISO 15926 is a standard for data integration, sharing, exchange, and hand-over between computer systems.	(Partridge et al., 2020)	https://www.iso.org/standard/29557.html
Framework	ISO 16757	Data structures for electronic product catalogues for building services.	(Mecharnia et al., 2023)	https://www.iso.org/standard/57613.html
Framework	RDF	Resource Description framework - standard models for data interchange on the Web.	(Mecharnia et al., 2023)	https://www.w3.org/RDF/
Protocol	Jena rules	Jena is a Java framework for building Semantic Web applications.	(Mecharnia et al., 2023)	https://jena.apache.org/index.html
Protocol	N3Logic	Notation 3 Logic is a logic that allows rules to be expressed in a Web environment. It uses N3 syntax and extends RDF with N3 syntax and a vocabulary of new predicates, which can be used to talk about the provenance of information, contents of documents on the Web, and provide a variety of useful functionality such as string, cryptographic, and mathematical functions.	(Mecharnia et al., 2023)	https://www.w3.org/DesignIssues/Notation3

Conceptual resources

Table A4.3 Conceptual resources

CDF Category	Name	Description	Source	URL
Model	CEN EN 17632	Semantic modelling and linking (SML): addresses syntactic and semantic interoperability for information describing assets going through their lifecycle in the built environment	(Mecharnia et al., 2023)	https://standards.iteh.ai/catalog/standards/cen/512f6571-2a12-4c4f-9027-793be26b1af5/pren-17632?srsltid=AfmBOopfAHiz35nurETu4hPXA52wp2nAS4qdljTLirHRhlYbNPyCpQVo
Model	CityGML	The CityGML standard defines a conceptual model and exchange format for the representation, storage and exchange of virtual 3D city models.	(Mecharnia et al., 2023)	https://www.ogc.org/standard/citygml/
Model	GML	Geography Markup Language	(Mecharnia et al., 2023)	https://www.ogc.org/standard/gml/
Model	Haystack	Project Haystack is an open source suite of technologies for modelling IoT data	(Mecharnia et al., 2023)	https://www.project-haystack.org/
Model	IFC	Standardized Digital Description of the Built Environment	(Mecharnia et al., 2023)	https://technical.buildingsmart.org/standards/ifc/#:~:text=What%20is%20IFC%3F,including%20buildings%20and%20civil%20infrastructure.
Model	IndoorGML	IndoorGML is an OGC standard for an open data model and XML schema for indoor spatial information. It aims to provide a common framework of representation and exchange of indoor spatial information	(Mecharnia et al., 2023)	https://www.ogc.org/standard/indoorgml/

CDF Category	Name	Description	Source	URL
Model	InfraGML	Encoding of LandInfra in GML	(Mecharnia et al., 2023)	https://www.ogc.org/standard/infragml/
Model	LegalDocumentML	Use of XML in Legal Documents	(Mecharnia et al., 2023)	https://www.service-architecture.com/articles/xml/legal-xml.html
Model	LegalRuleML	LegalRuleMl is based on the open standard RuleML to represent the logical content and semantics of the document. It was proposed to extend RuleML with formal features specific to legal norms, guidelines, policies and reasoning. It uses Extensible Markup Language (XML) to express rules in the legal domain and to manage legal resources.	(Mecharnia et al., 2023)	https://github.com/oasis-tcs/legalruleml
Model	LinkML	Linked Data Modelling Language (LinkML) is a flexible modelling language that allows defining schemas in YAML to describe the structure of data. Additionally, it is a framework for validating data in a variety of formats (JavaScript Object Notation (JSON), RDF, Tabulation-Separated Values (TSV)), with generators for compiling LinkML schemas to other frameworks.	(Mecharnia et al., 2023)	https://linkml.io/
Model	NEN 2660:2022	Rules for information modelling of the built environment - Part 1: Conceptual models. This standard describes terminology and general rules for an information system for the building field. The standard lays down rules for entities, attributes and models. Part 2: Practical configuration, extension and implementation of NEN 2660-1.	(Mecharnia et al., 2023)	https://www.nen.nl/en/nen-2660-1-2022-nl-291666
Model	OWL	Ontology Web Language - Semantic Web language designed to represent rich and complex knowledge about things, groups of things, and relations between things.	(Mecharnia et al., 2023)	https://www.w3.org/2001/sw/wiki/OWL
Model	Xplanung	XPlanung is the data standard and data exchange format for IT procedures relating to spatial planning, state and regional planning, urban land use planning and landscape planning in Germany	(Mecharnia et al., 2023)	https://www.smart-city-dialog.de/en/events/iscn-global-mixer-xplanung-data-standard-interoperable-

CDF Category	Name	Description	Source	URL
				urban-planning-processes#:~:text=XPlanung%20is%20the%20data%20standard,and%20landscape%20planning%20in%20Germany.
Model	RSM	RailSystemModel (RSM) provides a structural backbone model to foster digital continuity across railway domains and business processes.		https://rsm.uic.org/doc/rsm/rsm-1-2/
Model	Transmodel	CEN European Reference Data Model for Public Transport Information Transmodel provides an abstract model of common public transport concepts and data structures that can be used for timetabling, fares, operational management, real-time data, journey planning, etc.		https://transmodel-cen.eu/
Model	CIM	The Common Information Model (CIM) is a standard developed to facilitate the exchange and integration of information within different computer systems and across various applications in diverse industries. It provides a unified and consistent representation of data and relationships between data elements in an object-oriented manner.	(Partridge et al., 2020)	https://www.devx.com/terms/common-information-model/#:~:text=The%20Common%20Information%20Model%20(CIM)%20is%20an%20open%20standard%20that,their%20specific%20technology%20or%20platform.
Representation	BIMQL	A framework for a domain specific, open query language for building information models, intended for selecting, updating and deleting of data stored in Industry Foundation Classes models. Designed for Structured non-RDF Data	(Mecharnia et al., 2023)	https://doi.org/10.1016/j.aei.2013.06.001
Representation	BimSPARQL	Domain-specific functional SPARQL extensions for querying RDF building data	(Mecharnia et al., 2023)	https://osf.io/v5enm/

CDF Category	Name	Description	Source	URL
Representation	Datalog	Datalog is a declarative logic programming language. While it is syntactically a subset of Prolog, Datalog generally uses a bottom-up rather than top-down evaluation model. This difference yields significantly different behaviour and properties from Prolog. Datalog also supports negation in the rules.	(Mecharnia et al., 2023)	https://dbpedia.org/page/Datalog
Representation	EXPRESS	The EXPRESS Definition Language for IFC Development: is a conceptual schema language which provides for the specification of classes belonging to a defined domain, the information or attributes pertaining to those classes (colour, size, shape, etc.) and the constraints on those classes (unique, exclusive etc.). EXPRESS is formalized in the ISO Standard for the Exchange of Product model STEP (ISO 10303).	(Mecharnia et al., 2023)	https://standards.buildingsmart.org/documents/Implementation/The_EXPRESS_Definition_Language_for_IFC_Development.pdf
Representation	GeoSPARQL	Designed Semantic Data	(Mecharnia et al., 2023)	https://www.ogc.org/standard/geosparql/
Representation	ISO 10303	Specifies an exchange format that allows product data described in the EXPRESS language to be transferred from one computer system to another	(Mecharnia et al., 2023)	https://www.iso.org/obp/ui/#iso:std:iso:10303:-1:en
Representation	KBim Code	KBimCode or Korea BIM (KBIM) is a specialized language designed to represent Korean Building codes in an explicit and machine-readable format using a scripting language. This approach separates the process of creating rules from the traditional dependence on rule-checking software	(Mecharnia et al., 2023)	https://doi.org/10.1016/j.jcde.2018.08.002
Representation	KBVL	KBim Visual Language (KBVL) is an approach that employs visual symbols to create a machine-readable building code. This visual language approach is advantageous in that it is easy to use for those without programming expertise, thanks to its use of visual symbols, and is highly intuitive due to its user-defined level of visualization.	(Mecharnia et al., 2023)	https://doi.org/10.22260/ISARC2017/0058
Representation	Prolog	Prolog or PROgramming in LOGic is a descriptive language which is used to solve problems that involve objects and relationships between objects. It has been used for various applications including natural language understanding and reasoning. Unlike conventional programming languages, Prolog focuses more on describing facts and relationships rather than defining a sequence of steps to solve a problem.	(Mecharnia et al., 2023)	https://www.iso.org/standard/21413.html

CDF Category	Name	Description	Source	URL
Representation	QL4BIM	Advanced query language for building information models designed for Structured non-RDF Data	(Mecharnia et al., 2023)	https://github.com/SimonDaum/QL4BIM
Representation	RASE	The foundation for RASE is using markup based on four operators: requirement (R), applicability (A), selection (S) and exceptions (E). Briefly, applicability, selection and exception define the scope of the decision and the requirements define the decision itself. This is a semantic-based concept to transform normative documents into a well-defined rule which can be implemented into BIM/IFC-based model-checking software.	(Mecharnia et al., 2023)	http://www.aec3.eu/require1/Help_en-GB/help_en-GB_200.html
Representation	RuleML	Rule Markup Language was developed to express both forward and backward rules in XML for deduction, rewriting, and further inferential transformational tasks.	(Mecharnia et al., 2023)	https://www.ruleml.org/
Representation	SHACL	SHApes Constraint Language (SHACL) is a language for describing and validating RDF graphs. This validation can ensure the conformance of RDF data to a defined schema.	(Mecharnia et al., 2023)	https://www.w3.org/TR/shacl/
Representation	ShEx	Shape Expressions (ShEx) is a structural schema language for RDF graphs. It allows defining datatype constraints and to describe profiles of data.	(Mecharnia et al., 2023)	https://shex.io/
Representation	SPARQL	SPARQL can be used to express queries across diverse data sources, whether the data is stored natively as RDF or viewed as RDF via middleware. SPARQL contains capabilities for querying required and optional graph patterns along with their conjunctions and disjunctions. SPARQL also supports aggregation, subqueries, negation, creating values by expressions, extensible value testing, and constraining queries by source RDF graph.	(Mecharnia et al., 2023)	https://www.w3.org/TR/sparql11-query/
Representation	SPIN	SPARQL Inferencing Notation (SPIN) is a SPARQL-based rule and constraint language for the Semantic Web. SPIN is also a mechanism to represent reusable SPARQL queries as templates and to define new SPARQL functions with a web-friendly syntax. It is considered as the predecessor of SHACL.	(Mecharnia et al., 2023)	https://spinrdf.org/
Representation	SWRL	Semantic Web Rule Language (SWRL) is a combination of the OWL DL and OWL Lite sublanguages with the Binary Dialog RuleML sublanguage of the RuleML. This extends OWL axioms with Horn-like rules (rules which represent implications between an antecedent (body) and consequent (head)).	(Mecharnia et al., 2023)	https://www.w3.org/submissions/SWRL/

CDF Category	Name	Description	Source	URL
Representation	VCCL	Visual Compliance Checking Language (VCCL) is a programming language specifically designed for creating verification and checking procedures that conform to established standards or guidelines.By utilizing digital building information, VCCL can perform compliance checks in a fully or partially automated manner.	(Mecharnia et al., 2023)	https://www.itcon.org/paper/2016/25
Representation	CanML+CHARM	ConML is a conceptual modelling language that has been constructed from scratch with three major goals in mind: - Ease of use for non-experts in information technologies. - Simplicity. - Expressiveness in complex domains, such as those in the humanities. - Capturing "soft" issues such as temporality, subjectivity and vagueness. CHARM is a cultural heritage abstract reference model that extends ConML.	(Partridge et al., 2020)	http://www.conml.org/
Representation	UML	The Unified Modelling Language (UML) is a general-purpose, developmental, modelling language in the field of software engineering that is intended to provide a standard way to visualize the design of a system.	(Partridge et al., 2020)	https://www.iso.org/standard/32620.html
Schema	ISO 29481-3	ISO 29481-3:2022 Building information models — Information delivery manual Part 3: Data schema is the technical addition to the methodology set out in ISO 29481-1. It defines a specification to store, exchange and read information delivery manual (IDM) specifications in a standardized and machine-readable way.	(Poirier et al. 2022)	https://www.iso.org/standard/81261.html
Schema	ADMS	ADMS (Asset Description Metadata Schema) is used to describe semantic assets as highly reusable metadata	(Mecharnia et al., 2023)	https://www.w3.org/TR/vocab-adms/#:~:text=ADMS%2C%20the%20Asset%20Description%20Metadata,that%20are%20used%20for%20eGovernment
Schema	COBie	The Construction-Operations Building information exchange (COBie) standard defines information for assets that are delivered as part of a facility construction project and is used to document the data for the BIM process.	(Mecharnia et al., 2023)	https://www.wbdg.org/bim/cobie

CDF Category	Name	Description	Source	URL
Schema	COINS Building Information System schema	The Construction Industry Solutions (COINS) standard has a built-in structure to extend the central schema with sub-models (reference frameworks) that focus on specific topics for certain particular applications	(Mecharnia et al., 2023)	https://accordproject.eu/wp-content/uploads/2023/09/ACCORD_D2.1_Technical_Report_Existing_Models.pdf
Schema	ISO 16739	Specifies a conceptual data schema and an exchange file format for Building Information Model (BIM) data.	(Mecharnia et al., 2023)	https://www.iso.org/standard/84123.html
Schema	JSON Schema	JSON Schema is a declarative language that enables annotation and validation of JSON documents. JSON Schema Core defines the basic foundation of JSON Schema, and JSON Schema Validation defines the validation keywords of JSON Schema	(Mecharnia et al., 2023)	https://json-schema.org/
Schema	RDFS	RDF Schema (RDFS) is an extension of the RDF that enables the creation of vocabularies and ontologies for the Semantic Web. RDFS facilitates the definition of classes and properties that govern the structure and relationships of resources within an RDF graph.	(Mecharnia et al., 2023)	https://www.w3.org/TR/rdf-schema/
Schema	XML Schema (XSD)	XML Schema describes the structure of an XML document. XML Schema language is also referred to as XML Schema Definition. XML Schema Definition Language (XSD) offers facilities for describing the structure and constraining the contents of XML documents, including those which exploit the XML Namespace facility	(Mecharnia et al., 2023)	https://en.wikipedia.org/wiki/XML_Schema_(W3C)
Schema	Schema.org	Schema.org is a collaborative, community activity with a mission to create, maintain, and promote schemas for structured data on the Internet, on web pages, in email messages, and beyond.	(Partridge et al., 2020)	https://schema.org/
Schema	SKOS	SKOS is an area of work developing specifications and standards to support the use of knowledge organization systems (KOS) such as thesauri, classification schemes, subject heading systems and taxonomies within the framework of the Semantic Web.	(Partridge et al., 2020) (Mecharnia et al., 2023)	https://www.w3.org/2004/02/skos/

Procedural resources

Table A4.4 Procedural resources

CDF Category	Name	Description	Source	URL
Requirement	ISO 7817-1	ISO 7817-1:2024 Building information modelling — Level of information need — Concepts and principles specifies concepts and principles to establish a methodology for specifying level of information need and information deliveries in a consistent way when using building information modelling (BIM).	(Poirier et al. 2022)	https://www.iso.org/standard/82914.html
Specification	Information Delivery Specification (IDS)	Information Delivery Specification (IDS) by buildingSMART International are a set of "computer interpretable document that defines the Exchange Requirements of model-based exchange. It defines how objects, classifications, properties, and even values and units need to be delivered and exchanged. " The concept of information specification/information delivery specification formalizes information requirements into a computable framework.	(Poirier et al. 2022)	https://github.com/buildingSMART/IDS
Specification	ISO 12911	ISO 12911:2023 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Framework for specification of BIM implementation	(Poirier et al. 2022)	https://www.iso.org/standard/79692.html
Specification	3DTiles	3D Tiles is an open specification for sharing, visualizing, fusing, and interacting with massive heterogenous 3D geospatial content across desktop, web, and mobile applications. 3D Tiles are designed for streaming and rendering massive 3D geospatial content such as photogrammetry, 3D Buildings, BIM/CAD, Instanced Features, and Point Clouds .	(Mecharnia et al., 2023)	https://www.ogc.org/standard/3dtiles/
Specification	Indexed 3D Scene Layers (I3S)	A container for arbitrarily large amounts of heterogeneously distributed 3D geographic data.	(Mecharnia et al., 2023)	https://www.ogc.org/standard/i3s/

Practice/Methodological resources

Table A4.5 Practice resources

CDF Category	Name	Description	Source	URL
Guidelines	buildingSMART Canada Practice Manual for BIM	The bSC Practice manual provides a general background on the uses and benefits of BIM and provides guides on how to implement BIM within organizations and across collaborative projects.	(Poirier et al. 2022)	https://buildingsmart.gilmoreglobal.com/en/product/adecc971-8e98-4d0a-bbde-f185d2bc1940
Guidelines	buildingSMART Canada PxP Toolkits	These PxP (Project Execution Plan) Toolkits consist of three volumes covering the design development phase, construction phase, and lastly, the handover and maintenance phase. These volumes can be purchased separately or together as a complete guide. Each toolkit contains a collection of real-world examples of BIM at each phase of development, creating a composite illustrative project.	(Poirier et al. 2022)	https://buildingsmart.gilmoreglobal.com/en/category/528933fe-437c-4916-8916-f05ca78065fd
Management	IBC BIM 100:2014	The Institute of BIM in Canada (IBC) Contract Appendix is a fillable document that was created to help industry professionals become more familiar with the overlap between disciplines and information which occurs with the use of BIM.	(Poirier et al. 2022)	https://buildingsmart.gilmoreglobal.com/en/category/97d4a59a-0573-4ec5-b029-c6ea56f06d85
Management	IBC BIM 201:2014	The appendix provides standard form contracts with information regarding industry best practices, alignment with BIM ISO 19650, and how to advance the industry's use of BIM.	(Poirier et al. 2022)	https://buildingsmart.gilmoreglobal.com/en/category/97d4a59a-0573-4ec5-b029-c6ea56f06d85
Management	ISO 19650-1	ISO 19650-1:2018 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 1: Concepts and principles "[...] outlines the concepts and principles for information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series." This document provides recommendations for a framework to manage	(Poirier et al. 2022)	https://www.iso.org/standard/68078.html

CDF Category	Name	Description	Source	URL
		information including exchanging, recording, versioning and organizing for all actors."		
Management	ISO 19650-2	ISO 19650-2:2018 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 2: Delivery phase of the assets "[...] specifies requirements for information management, in the form of a management process, within the context of the delivery phase of assets and the exchanges of information within it, using building information modelling."	(Poirier et al. 2022)	https://www.iso.org/standard/68080.html
Management	ISO 19650-3	ISO 19650-3:2020 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 3: Operational phase of the assets "[...] specifies requirements for information management, in the form of a management process, within the context of the operational phase of assets and the exchanges of information within it, using building information modelling."	(Poirier et al. 2022)	https://www.iso.org/standard/75109.html
Management	ISO 19650-4	ISO 19650-4:2022 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 4: Information exchange "[...] complements parts 1-3 & 5 by providing the explicit process and criteria for an individual information exchange." It is currently under development.	(Poirier et al. 2022)	https://www.iso.org/standard/78246.html
Methodology	ISO 23386	ISO 23386:2020 - Building information modelling and other digital processes used in construction — Methodology to describe, author and maintain properties in interconnected data dictionaries "establishes the rules for defining properties used in construction and a methodology for authoring and maintaining them, for a confident and seamless digital share among stakeholders following a BIM process."	(Poirier et al. 2022)	https://www.iso.org/standard/75401.html
Methodology	ISO 29481-1	ISO 29481-1:2016 Building information models — Information delivery manual Part 1: Methodology and format specifies a methodology that links	(Poirier et al. 2022)	https://www.iso.org/standard/60553.html

CDF Category	Name	Description	Source	URL
		the business processes undertaken during the construction of built facilities with the specification of information that is required by these processes, and a way to map and describe the information processes across the lifecycle of construction works.		
Security	ISO 19650-5	ISO 19650-5:2020 - Organization and digitization of information about buildings and civil engineering works, including building information modelling (BIM) — Information management using building information modelling — Part 5: Security-minded approach to information management "[...] specifies the principles and requirements for security-minded information management at a stage of maturity described as "building information modelling (BIM) according to the ISO 19650 series," and as defined in ISO 19650-1, as well as the security-minded management of sensitive information that is obtained, created, processed and stored as part of, or in relation to, any other initiative, project, asset, product or service. It addresses the steps required to create and cultivate an appropriate and proportionate security mindset and culture across organizations with access to sensitive information, including the need to monitor and audit compliance."	(Poirier et al. 2022)	https://www.iso.org/standard/74206.html
Security	ISO 27000	ISO/IEC 27000:2018 provides the overview of information security management systems (ISMS). It also provides terms and definitions commonly used in the ISMS family of standards. This document is applicable to all types and sizes of organization (e.g., commercial enterprises, government agencies, not-for-profit organizations).	(Poirier et al. 2022)	https://www.iso.org/standard/73906.html
Security	ISO 27001	The ISO/IEC 27001 standard provides companies of any size and from all sectors of activity with guidance for establishing, implementing, maintaining and continually improving an information security management system.	(Poirier et al. 2022)	https://www.iso.org/standard/27001
Template	ISO 23387	ISO 23387:2020 - Building information modelling (BIM) — Data templates for construction objects used in the lifecycle of built assets — Concepts and principles "sets out the principles and structure for data templates for construction objects. It is developed to support digital processes using	(Poirier et al. 2022)	https://www.iso.org/standard/75403.html

CDF Category	Name	Description	Source	URL
		machine-readable formats using a standard data structure to exchange information about any type of construction object, e.g., product, system, assembly, space, building, etc., used in the inception, brief, design, production, operation and demolition of facilities."		
Template	eCOB	The eCOB standard for the Creation of BIM Objects is an instrument for generating generic or industrial BIM objects with an information structure, facilitating interoperability between BIM programs throughout the entire lifecycle of the construction. eCOB® is based on IFC, the European Harmonized regulatory context and the National regulations applicable to construction projects in a specific country. At this time it is adapted to Spanish regulations (Technical Building Code, EHE, etc.).	(Mecharnia et al., 2023)	https://ecobject.com/ca/
Template	ISO 22057	Data templates for the use of electronic product dictionaries	(Mecharnia et al., 2023)	https://www.iso.org/standard/72463.html
Template	ISO 23387	Building information modelling (BIM) — Data templates for construction objects used in the lifecycle of built assets — Concepts and principles		https://www.iso.org/standard/75403.html

Services Resources

Table A4.6 Service resources

CDF Category	Name	Description	Source	URL
API	BCF REST API	The Open CDE workgroup has developed the BCF-API within buildingSMART International to enable interoperability with the BCF standard	(Mecharnia et al., 2023)	https://github.com/buildingSMART/BCF-API
API	oBIX	Open Building Information Exchange enables the mechanical and electrical control systems in buildings to communicate with enterprise applications, and to provide a platform for developing new classes of applications that integrate control systems with other enterprise functions.	(Mecharnia et al., 2023)	http://www.obix.org/
API	OGC - FEATURES API	Features is a multi-part standard that offers the capability to create, modify, and query spatial data on the Web	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/features/
API	OGC 3D GEOVOLUMES API	Used for access and transfer of 3D geospatial content over the internet	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/geovolumes/
API	OGC API - PROCESSING	Allows for processing tools to be called and combined from many sources and applied to data in other OGC API resources	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/processes/
API	OGC API - RECORDS	Offers the capability to create, modify, and query metadata on the Web	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/records/
API	OGC DISCRETE GLOBAL GRID SYSTEMS API	An API for accessing data organized according to a Discrete Global Grid System (DGGS).	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/dggs/
API	OGC MAPS API	Maps draft specification describes an API that can serve spatially referenced and dynamically rendered electronic maps	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/maps/
API	OGC TILES - API	The OGC API — Tiles standard defines building blocks for creating Web APIs that support the retrieval of geospatial information as tiles.	(Mecharnia et al., 2023)	https://ogcapi.ogc.org/tiles/
API	open CDE (CEN WI 442032)	Common Data Environments (CDE) for BIM projects –Open data exchange between platforms of different vendors via an open CDE API	(Mecharnia et al., 2023)	https://github.com/buildingSMART/OpenCDE-API

CDF Category	Name	Description	Source	URL
API	Uniclass API	The Uniclass API allows accessing Uniclass in your own platform, making it even easier to apply to your day to day processes.	(Mecharnia et al., 2023)	https://www.thenbs.com/our-tools/uniclass/api
Environment	DIN 91391	DIN 91391 - Common Data Environments (CDE) for BIM projects - Function sets and open data exchange between platforms of different vendors. Common Data environments are one of the key components of collaborative project delivery and information management supported through ISO 19650.	(Poirier et al. 2022)	https://www.dinmedia.de/en/technical-rule/din-spec-91391-1/302483139
Environments	BIMRL	BIM Rule Language (BIMRL) is a complete environment for data, rule definition, and rule execution.	(Mecharnia et al., 2023)	https://www.itcon.org/papers/2016_24.content.02464.pdf
Environments	DIN SPEC 91391	Common Data Environments (CDE) for BIM projects - Function sets and open data exchange between platforms of different vendors - Part 1: Components and function sets of a CDE	(Mecharnia et al., 2023)	https://www.din.de/en/innovation-and-research/din-spec-en/current-din-specs/wdc-beuth:din21:302483139
Environments	Drools	Drools is a business-rule management system with forward and backward chaining. A forward chaining rule system starts with a fact and reacts to its changes, being a data-driven system. Contrarily, a backward-chaining rule system starts with a conclusion that needs to satisfy and continues the process until the initial conclusion or its sub-goals are satisfied, being a goal-driven system.	(Mecharnia et al., 2023)	https://github.com/kiegroup/drools
Environments	GS1 service	GS1 standards create a common foundation for business by uniquely identifying, accurately capturing and automatically sharing vital information about products, locations, assets and more. Businesses can also combine different GS1 standards to streamline business processes such as traceability.	(Mecharnia et al., 2023)	https://www.gs1.org/standards
Interface	buildingSMART Data Dictionary	The buildingSMART Data Dictionary (bSDD) is an online service that hosts classifications and their properties, allowed values, units and translations. The bSDD allows linking between all the content inside the database. It provides a standardized workflow to guarantee data quality and information consistency.	(Poirier et al. 2022)	https://www.buildingsmart.org/users/services/buildingsmart-data-dictionary/

CDF Category	Name	Description	Source	URL
Interface	buildingSMART International Use Case Management	Information uses "define what information is needed to deliver a specific project outcome". The buildingSMART International Use Case Management tool is a service that "[...] enables the capture, specification and exchange of best practices and makes them accessible to the entire built asset industry."	(Poirier et al. 2022)	https://ucm.buildingsmart.org/
Rule	BUNDLE	BUNDLE ("Binary decision diagrams for Uncertain reasoNing on Description Logic thEories") is a probabilistic reasoner that computes the probability of queries from a probabilistic knowledge base that follows the DISPONTE probabilistic semantics.	(Mecharnia et al., 2023)	http://owl.cs.manchester.ac.uk/tools/list-of-reasoners/
Rule	CEL	The Common Expression Language (CEL) is used in the Kubernetes API to declare validation rules, policy rules, and other constraints or conditions.	(Mecharnia et al., 2023)	https://kubernetes.io/docs/reference/using-api/cel/
Rule	Closed World Machine (CWM)-Euler Yap Engine (EYE)	EYE is a reasoning engine supporting the Semantic Web layers. It performs semibackward reasoning and it supports Euler paths. Via N3 it is interoperable with Cwm.	(Mecharnia et al., 2023)	https://eulersharp.sourceforge.net/
Rule	fuzzyDL	DL-Learner is a framework to perform machine learning rich semantic background knowledge (usually in description logics, hence the "DL" in its name).	(Mecharnia et al., 2023)	https://github.com/SmartDataAnalytics/DL-Learner/blob/develop/README-FuzzyDL
Rule	Jcel-Konclude	Konclude is a tableau-based reasoner for the Description Logic SROIQV(D), i.e.,SROIQ(D) + Nominal Schemas, and covers almost all features of the Web Ontology Language (OWL) 2 DL	(Mecharnia et al., 2023)	https://github.com/konclude/Konclude
Rule	Jess rules	Jess is a rule engine for the Java platform.	(Mecharnia et al., 2023)	http://alvarestech.com/temp/fuzzyjess/Jess60/Jess70b7/docs/index.html
Rule	ontop-HermiT-Clipper-DBOWL-Living Semantic Platform	SPARQL Description Logic reasoners	(Mecharnia et al., 2023)	http://owl.cs.manchester.ac.uk/tools/list-of-reasoners/

CDF Category	Name	Description	Source	URL
Rule	OwlOntDB-Mastro-DReW-HydrOWL-PAGOdA-RDFox	Datalog Rules Description Logic reasoners	(Mecharnia et al., 2023)	http://owl.cs.manchester.ac.uk/tools/list-of-reasoners/
Rule	pySHACL-SHaclEX-	A Python validator for SHACL.	(Mecharnia et al., 2023)	https://github.com/RDFLib/pySHACL
Rule	TORNADO-RuQAR-Racer-RDFox-Pellet-HermiT-Algernon-Pellet	SWRL Description Logic reasoners	(Mecharnia et al., 2023)	http://owl.cs.manchester.ac.uk/tools/list-of-reasoners/
Rule	TRILL-TRILLP-KARMA	Prolog Description Logic reasoners	(Mecharnia et al., 2023)	http://owl.cs.manchester.ac.uk/tools/list-of-reasoners/
Rule	VIDRE	Vienna Distributed Rules Engine (VIDRE) is a service-oriented business rules engine based on RuleML that enables enterprise applications to access business rules as easily as accessing a database, by exposing rules as Web services	(Mecharnia et al., 2023).	https://dsg.tuwien.ac.at/prototypes/ViDRE/ViDRE_index.html
Rule	WSClassifier (WSReasoner)-TrOWL-TReasoner-ELK-FaCT++-ELepHant-DRAOn-JFact-Snorocket-	DL clauses Description Logic reasoners	(Mecharnia et al., 2023)	http://owl.cs.manchester.ac.uk/tools/list-of-reasoners/

buildingSMART Canada is committed to supporting the digitalization of Canada's built asset industry by developing and helping promote the adoption of open, international standards and solutions.

buildingSMART Canada is the community for visionaries working to transform the design, construction, operation, and maintenance of Canada's built environment.

As a Canadian federally incorporated Not-for-Profit Corporation, the Canadian chapter of buildingSMART International provides the appropriate body and home for Canadian BIM and digital project and asset lifecycle delivery Standards and best practices development.

It exists to support the implementation of BIM in a way and at a pace that enables industry to successfully achieve its objectives and deliver value to Canadians.

Canada and Canadian professionals have a long history and reputation of collaboration and communication between countries and regions. The chapter continues to fulfill this role, supporting the development and application of standards from high-level to practical use.

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