openBIM Implementations for a Canadian Roadmap

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About buildingSMART Canada

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.

Contents

Definitions

BIM Collaboration Format (BCF):
allows different BIM applications to communicate model-based issues with each other by leveraging IFC data that have been previously shared among project collaborators. – buildingSMART International

Building Information Modeling (BIM):
a digital representation of physical and functional characteristics of a facility. As such it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life-cycle from inception onward. – NBIMS-US

buildingSMART Data Dictionary (bsDD):
a dictionary or terminology library. Through bsDD, concepts, measurement units and properties are uniquely defined with their own unique identity, a so-called GUID (global unique identifier), which is a machine-readable code. – buildingSMART International

Common Data Environment (CDE):
agreed source of Information for any given project or Asset, for collecting, managing, and disseminating each Information Container through a managed process. – ISO 19650-1 (3.3.15).

Construction Operations Building Information Exchange (COBie):
a non-proprietary data format for the publication of a subset of BIM focused on delivering asset data rather than geometric information. It is formally defined as a subset of the IFC, but can also be conveyed using worksheets or relational databases. – Designing Buildings Wiki

Industry Foundation Classes (IFC):
An industry-specific data model schema to support transformation of information or data. – buildingSMART International

Information Delivery Specification (IDS):
a standard under development, defining exchange information requirement in a computer interpretable way. – buildingSMART International

Model View Definition (MVD):
a specific implementation level of IFC to describe facilitate a specific use or workflow. Because an MVD is being implemented by Software Vendors, MVDs are the base against which the MVD based Software Certification takes place. Software implementations are checked against the implementation agreements of an MVD. – buildingSMART International

openBIM:
a collaborative process that is inclusive of all participants, promoting interoperability to benefit projects and assets throughout their lifecycle. It is based on open standards and workflows that allow different stakeholders to share their data with any BIM compatible software. – buildingSMART International

Use-Case Management Service (UCM):
the UCM enables the capture, specification and exchange of best practices and makes them accessible to the entire built asset industry. – buildingSMART International

Executive Summary

This comprehensive research project investigates the transformative journey of the Canadian architecture, engineering, construction, owner, operator, and municipality (AECOOM) sectors as they adopt Building Information Modeling (BIM) and openBIM standards to digitalize the planning, design, construction, and management of built assets. With the digitalization of the AECOOM through BIM and data exchange standards, Canada aims to unlock decarbonization aspirations and requirements, optimize project outcomes, and lead in sustainable and digitized built asset industry.

Internationally, the adoption of openBIM standards and practices is fostering a more collaborative, transparent, and efficient development lifecycle. Canada's focus on interoperability and the ability for data to be exchanged across various software platforms positions it to benefit from enhanced digital workflow, and more reliable outcomes. By reviewing and engaging with buildingSMART International (bSI) chapters and other nations' approaches, this research project provides a comprehensive analysis, highlighting significant commonalities, patterns, and differences in openBIM methodologies.

As the industry marches towards a more digital, collaborative, and sustainable future, Canada stands to gain immensely from the lessons learned by other jurisdictions. By focusing on government initiatives, collaboration, education, and standardization, the country can position itself at the forefront of BIM and openBIM innovation, driving economic growth while fulfilling its environmental and societal commitments. The research project highlights the successful implementation of BIM within the AECOOM sector, offering benefits such as greater efficiency, reduced costs, enhanced collaboration, and improved decision-making.

It also outlines the pivotal project undertaken in collaboration with buildingSMART Canada (bSC) and various stakeholders within the AECOOM sector to assess the readiness of provinces and territories to adopt BIM and enable comprehensive standards and processes for its continued implementation.

openBIM serves as a holistic approach for a more sustainable and digitized built asset industry.

Drawing from international best practices, the research project suggests openBIM opportunities and interoperability challenges pertinent to Canada. The critical role of government-led initiatives, as seen in countries like the UK, Norway, and Singapore, has set the stage for industry-wide openBIM adoption. Additionally, the significance of advocating open standards, initiating collaborative efforts, establishing standardized terminology, and leveraging openBIM for enhanced sustainability is discussed.

Finally, as the Canadian AECOOM sectors commence this significant transformation, the comprehensive adoption of the Canadian BIM roadmap and its principles represents more than a foundational shift; it is a strategic step towards a more integrated, efficient, and sustainable future. This research project presents a series of final recommendations, derived from the key areas of the developed BIM roadmap. These recommendations were gathered from engaging sessions at the bSC National Summit in November 2023.

Project Objectives

The primary objective of this research project is a comprehensive investigation of openBIM and its interoperability requirements across international jurisdictions, with the aim of informing and shaping its implementation in Canada. To develop a cohesive strategy and corresponding guidance for the adoption of BIM standards and openBIM within Canada, an in-depth understanding of how Canadian jurisdictions manage and facilitate interoperability is essential. This includes a thorough assessment of the current state of BIM adoption, implementation, and maturity across Canada's provinces and territories. The project will culminate in the formulation of a series of recommendations, supported by a developed National BIM roadmap, to guide the country toward effective and efficient openBIM integration.

In summary, this research project is mainly focused on the following key objectives:

1 Review of International openBIM standards interoperability requirements, and Implementations

2 Identification of openBIM and interoperability opportunities to inform Canadian built asset industry

3 Assessment of BIM readiness across Canadian territories and provinces

4 A summary of final recommendations and National BIM Roadmap in Canada

Part 1:

Analysis of International openBIM Implementations to Inform Canadian Adoption

Looking at leading international jurisdictions, the focus was placed on nine primary countries:

1. Australia
2. Denmark
3. Finland
4. France
5. Japan

6. Norway
7. Singapore
8. The United Kingdom
9. The United States

The selection of these nine primary countries was based on several factors that make them prominent players in the field of openBIM and comparable to the Canadian built asset industry and openBIM initiatives.

Firstly, these countries have demonstrated a strong commitment to advancing BIM practices and have made significant contributions to the development and implementation of openBIM standards. They have actively invested in creating the necessary infrastructure, mandates, standards, and technologies to support openBIM adoption.

Secondly, these countries represent a diverse range of geographical locations and cultural contexts. This diversity ensures that the review encompasses a global perspective, considering different approaches, challenges, and successes related to openBIM implementation. The following sections incorporate findings from the initial review and engagements with international affiliates, presenting the latest developments in openBIM across the globe in alphabetical order.

Australia

In Australia, there's a strong interest in BIM and openBIM. However, many are concerned about how it works in practice. One of BIM's key advantages is its ability to support smooth teamwork and collaboration. Still, a major problem arises because there aren't universally agreed-upon standards for BIM content.

This means there are often differences in how properties are described, named, and categorized. These differences can slow down work and result in extra time needed to get everything aligned in a project.

To help with this issue, the non-profit group National Building Specifications (NATSPEC) has introduced a set of tools. These are made to improve the sharing of digital details between those involved in a project. By doing this, the goal is to make the BIM process more straightforward and help the Australian construction sector work more consistently and efficiently.
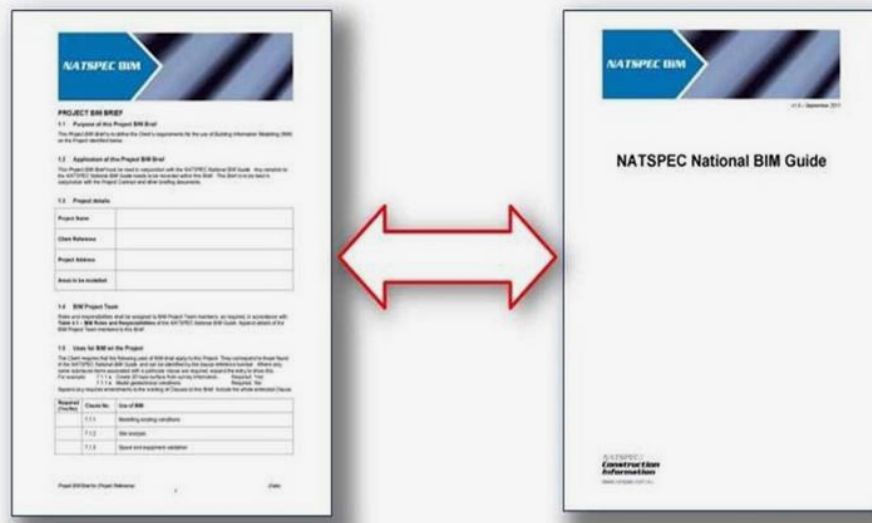
Figure 1. A project's brief should define project-specific requirements by reference to the general requirements of the NATSPEC National BIM Guide (Taken from NATSPEC)

The **NATSPEC National BIM Guide** is an exhaustive resource tailored for those new to the BIM world, as well as individuals holding strategic and high-level management roles. This guide dives deep into the realm of openBIM, giving readers a thorough understanding of its intricacies. Among its contents are appendices that detail ISO19650 resources, but with a unique twist – it's tailored specifically for the Australian context. The guide also sheds light on openBIM enablers, use cases, and critical information requirements. What sets this guide apart is its inclusion of editable templates. These templates, which are in alignment with AS ISO 19650, cater to asset information, exchange information, and product information needs (Figure 1). As a result, users find it incredibly practical for individual BIM projects, ensuring that their processes remain streamlined and efficient. Recognizing the ever-evolving nature of BIM processes, the NATSPEC National BIM Guide is not static. It undergoes regular updates to ensure it

remains relevant and up-to-date. This dynamic attribute ensures that professionals relying on the guide will always have the latest best practices at their fingertips. Serving as a one-stop-shop for all things BIM, this guide guarantees that users will be equipped with the knowledge and tools they need, reducing the risk of encountering unforeseen hiccups in their BIM projects Generator lies in its inclusivity. It isn't restrictive in its data sources. Users have the freedom to pick properties from a rich variety, be it IFC4, IFC 2×3, COBie, and more. Its holistic approach is evident in the way it integrates objects from IFC files and classification data from global standards like UniClass, Omniclass, Masterformat, Uniformat, and several others. Given its features and adaptability, the tool is not limited to just one type of user. Whether the user is a property owner, a member of a project team, a manufacturer, or part of a client company, the NATSPEC BIM Properties Generator offers immense value, facilitating extraction of meaningful data from various openBIM data formats.
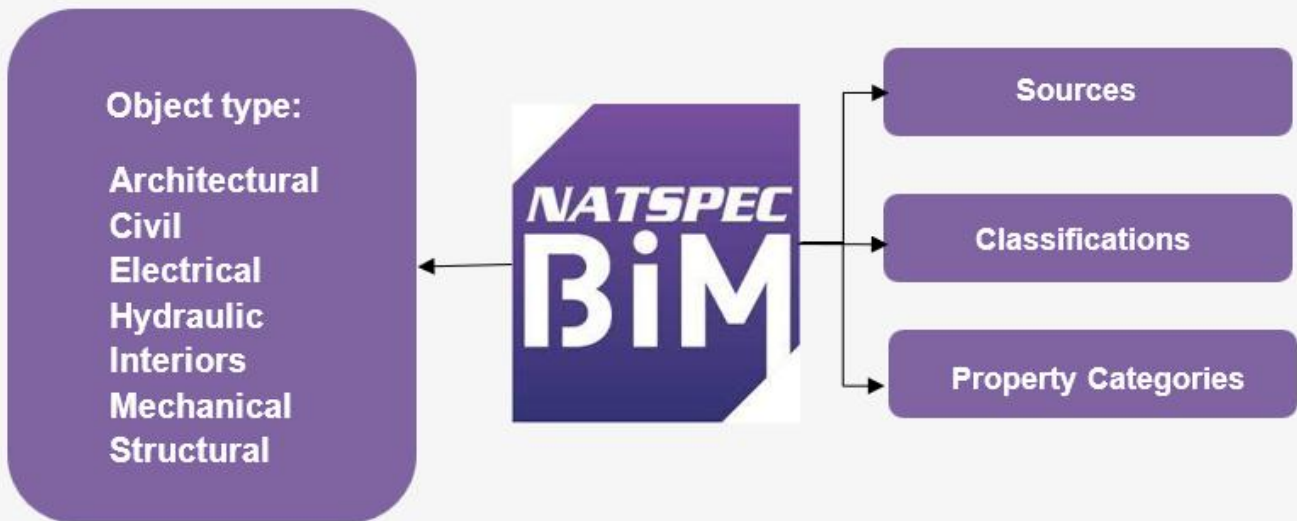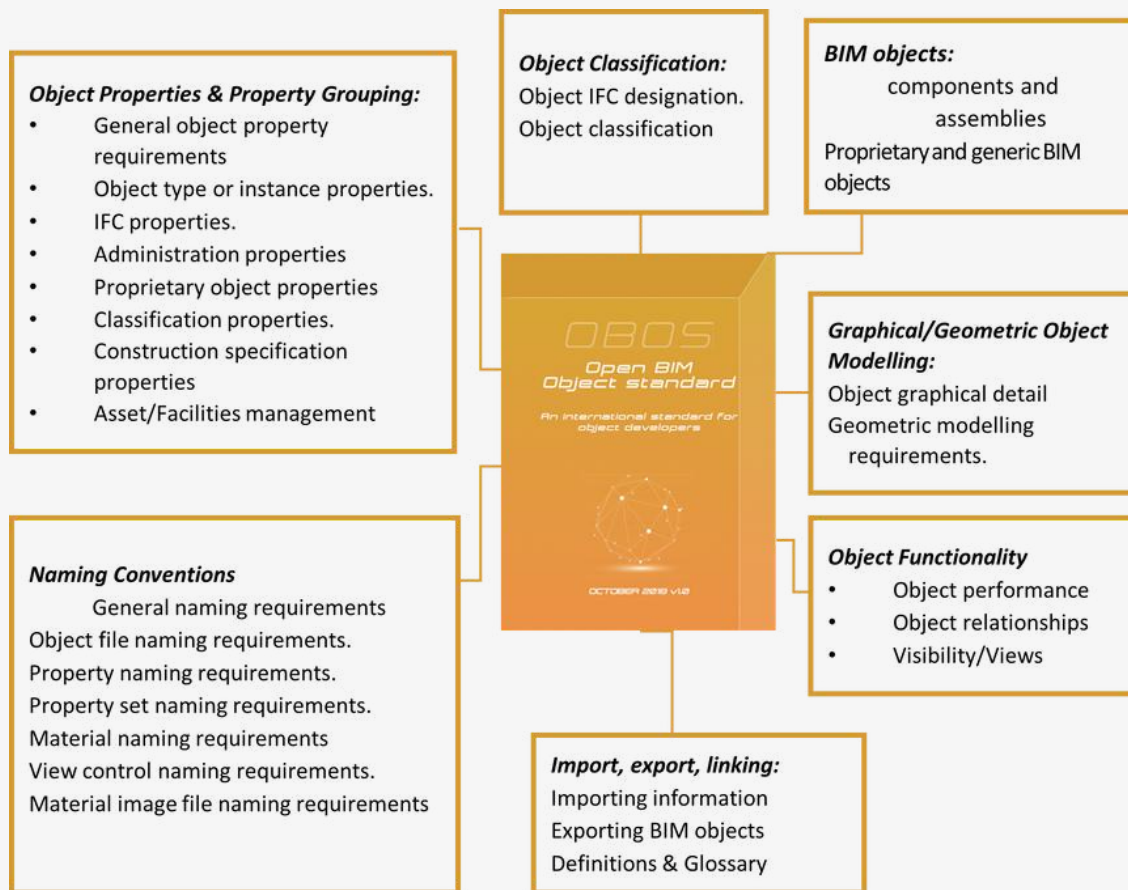

Figure 2:NATSPEC BIM Properties Generator user interface (Taken from NATSPEC)

Object Properties & Property Grouping:
- General object property requirements
- Object type or instance properties.
- IFC properties.
- Administration properties
- Proprietary object properties
- Classification properties.
- Construction specification properties
- Asset/Facilities management

Object Classification:
Object IFC designation.
Object classification

BIM objects:
components and assemblies
Proprietary and generic BIM objects

Graphical/Geometric Object Modelling:
Object graphical detail
Geometric modelling requirements.

Object Functionality
- Object performance
- Object relationships
- Visibility/Views

Naming Conventions
General naming requirements
Object file naming requirements.
Property naming requirements.
Property set naming requirements.
Material naming requirements
View control naming requirements.
Material image file naming requirements

Import, export, linking:
Importing information
Exporting BIM objects
Definitions & Glossary

Figure 3:OBOS topics and requirements

Generator lies in its inclusivity. It isn't restrictive in its data sources. Users have the freedom to pick properties from a rich variety, be it IFC4, IFC 2×3, COBie, and more. Its holistic approach is evident in the way it integrates objects from IFC files and classification data from global standards like UniClass, Omniclass, Masterformat, Uniformat, and several others. Given its features and adaptability, the tool is not limited to just one type of user. Whether the user is a property owner, a member of a project team, a manufacturer, or part of a client company, the NATSPEC BIM Properties Generator offers immense value, facilitating extraction of meaningful data from various openBIM data formats.

Among the countries highlighted in this analysis, many are in the midst of tailoring or adopting such open standards. Taking Australia as an illustrative example, the nation has adopted the **Open BIM Object Standard (OBOS)** as its guiding adoption. This unique tool aligns seamlessly with the Properties Generator, but it is also documented for the purpose of aiding the creation of uniform BIM objects. The OBOS, detailed in a 32-page dossier, offers an exhaustive insight into numerous facets related to BIM. These include, but are not limited to, naming guidelines, legal frameworks, IFC classifications, object attributes, functionalities, and the dos and don'ts of data import, export, and interlinking (as shown in Figure 3). In addition, a thorough glossary provides clarity on various terms and IFC element categories, serving as a quick reference for professionals. The roots of these resources trace back to a collaborative venture, where myriad seasoned stakeholders from the construction sector shared their insights. As the needs of the construction sector evolve, this repository will be continually refined and updated to ensure its relevance and efficacy.

Denmark

Denmark has actively developed Information Communication Technologies (ICT) to promote openBIM processes and has established a thorough framework for embracing global open standards, especially in its construction sector. buildingSMART Denmark (bSDK) leads the nation's openBIM advancements. bSDK provides several significant benefits to professionals in the construction industry.

Firstly, it paves the way for global collaboration, enabling construction firms to venture into international partnerships, thus driving global industry growth. The chapter emphasizes the improved means of exchanging 3D models and BIM, streamlining the process for quality checks and ensuring flawless project execution.

Additionally, the introduction of specialized tools aids in efficiently managing project-related issues, enhancing the error-correction procedure while maintaining thorough documentation for transparency. The seamless transfer of essential project details from consultants to contractors is also facilitated, making tasks like quantity extraction more straightforward.

For clients and operators, the tools offer streamlined digital documentation that can be effortlessly integrated into facility management (FM) systems, simplifying the upkeep of constructed establishments.

Professionals can also leverage the tools for creating BIM-based surveys through technologies like 3D scanning and drone-based photogrammetry, which ensures precise data collection of existing buildings. The comprehensive documentation provided supports sustainable construction approaches, encouraging resource conservation. Another advantage lies in software flexibility, allowing users the freedom to choose from various programs without being tied down to specific formats, promoting innovation.

Lastly, the emphasis on data ownership ensures long-term data access and security, emphasizing the preservation and protection of data for the future.

In the evolving landscape of digital construction and building technologies, Denmark is stepping up its game. A significant voice in this transformation is Peter Bo Olsen, a standardization specialist at Molio and a dedicated member of bSDK. Olsen's faith in bSDK's mission is unwavering. He elaborates on its importance in establishing a coherent approach to openBIM in the country:

> **"An honest and professional dissemination of good practice with openBIM is the foundation, next come the role models in the form of companies and experts with a practice with openBIM that provides value and can be told. Both parts must be used in networks that discuss openBIM as part of the solution to the companies' challenges in both the short and long term. All of the above takes time, a long time, because people are busy with everything else [...] Meanwhile, bSDK develops openBIM guides and instructions together with the industry, and existing good practice with openBIM at the individual company is shared and discussed with the industry at workshops and communicated in articles."**

> *Peter Bo Olsen*

As Olsen pointed out, such guides and regulations can be found in some valuable documents published by bSDK (Figure 4). These encompass IFC import and export guides, IDM method guide, BCF guide, as well as sample BIM models like the Molio-Huset Revit models and Molio-Huset ArchiCAD models. Notably, these guides are complemented with IFC iterations spanning architectural, structural, and plumbing components. Additionally, the cache of resources also contains IDS examples and a comprehensive look into Danish building codes and regulations.

Figure 4. bSDK openBIM publications (adapted from bSDK)
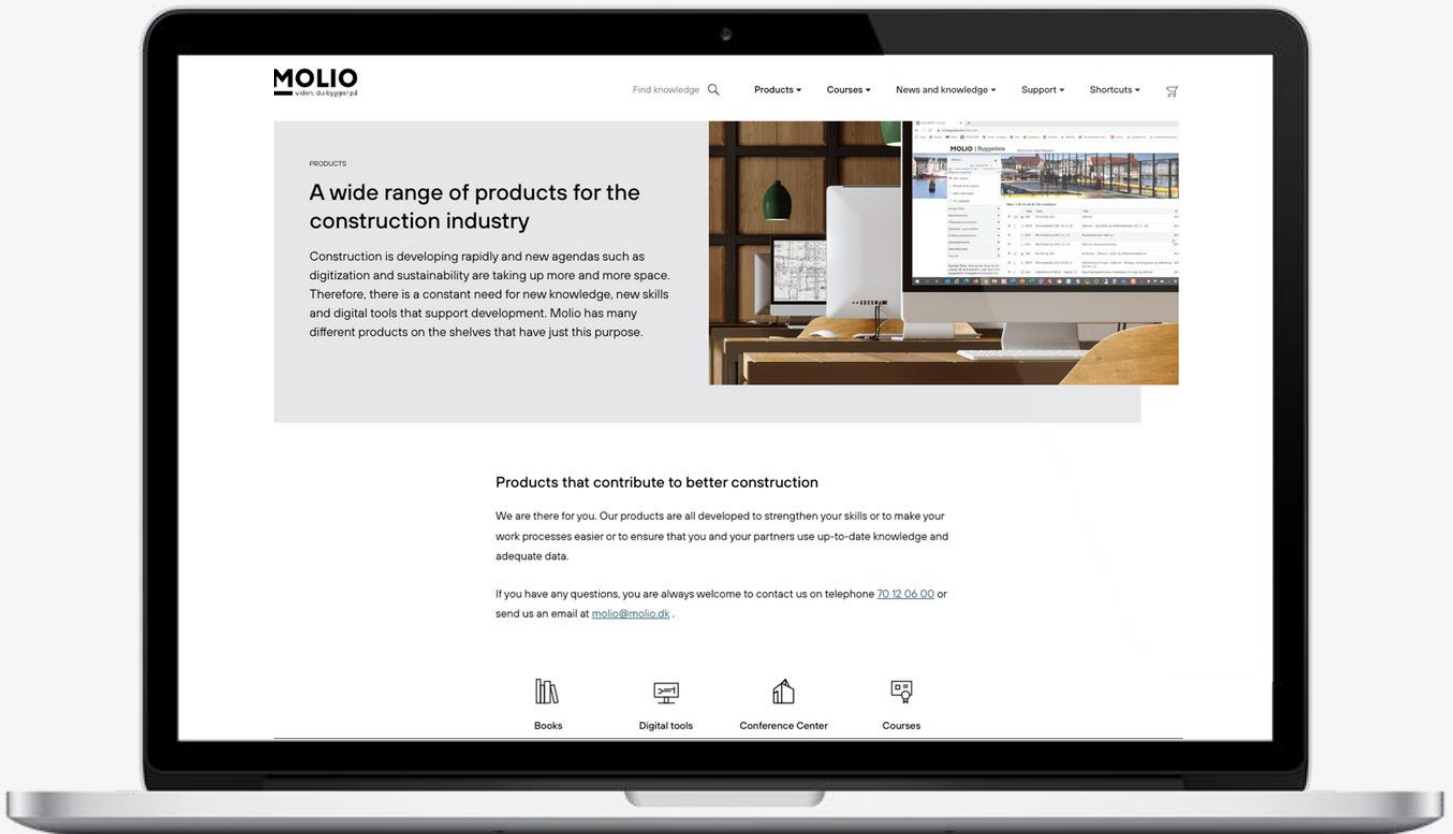
Figure 5. Molio's resources for openBIM (Taken from Molio.dk)

In January 2020, bSDK founded Molio, setting it up as a non-profit center of knowledge dedicated to the aggregation of openBIM expertise (Figure 5). This is achieved by employing various digital tools, setting standards, offering courses, publishing books, and providing guidelines specifically tailored for the construction sector.

Molio's primary objective is to champion the widespread adoption of openBIM practices, ensuring the construction industry readily integrates standard procedures and embraces emerging technologies.

Figure 6. LeksiCON user interface (Taken from Molio)

Molio has introduced a BIM data dictionary called LeksiCON (Figure 6), designed as a standard digital dictionary for the Danish construction industry to describe building components and their characteristics. By unifying terminology, it promotes seamless data sharing across the entire construction lifecycle. LeksiCON, reflecting the "Danish context," features 42 data templates, each representing specific building components as described in Molio's Building Part Specification. These templates are grouped into four primary categories:

(1) Molio's updated building part standards,
(2) classification and identification standards including CCS, CCI, BIM7AA, and BIMTypeCode,
(3) operational data like maintenance and performance, and
(4) an upcoming section on Environmental Product Declarations, highlighting a move towards eco-conscious construction.

LeksiCON is a comprehensive resource rooted in both national and international standards, as well as time-honored Danish construction practices. It aligns with key CEN and ISO standards tailored for Danish construction, ensuring the terminology and practices resonate with international benchmarks, while also catering to Denmark-specific needs. Additionally, it incorporates European harmonized product standards for CE marking and integrates Danish building regulations, supplements, and de facto standards to offer a full picture of the Danish construction landscape. Crucially, LeksiCON's data governance, encompassing data quality, structure, and maintenance, strictly adheres to pivotal standards such as the DS/EN ISO series. These standards emphasize data management in the construction domain, with a particular focus on BIM and digital construction processes, ensuring the right data is available at the necessary stages of a project.

Finland

In Finland, multiple governmental bodies and agencies play an active role in openBIM's evolution. Key government bodies, including the Ministry of the Environment, buildingSMART Finland (bSF), Finish Transport Infrastructure Agency, and Senate Properties, are at the forefront of shaping BIM's direction.

These groups create policies and strategies to encourage BIM's use in areas like construction, design, and infrastructure, aiming to boost cooperation, productivity, and eco-friendliness. In addition to governmental agencies, educational and research institutions significantly raise BIM awareness and provide training. Esteemed institutions like Aalto University, Tampere University of Technology, and VTT Technical Research Centre of Finland lead in research, innovating openBIM practices, and offering dedicated BIM courses. These centers of learning promote collaboration among scholars, industry experts, and government representatives, propelling openBIM progress.

Annina Lehikoinen, Business Manager at bSF, highlighted the intricate dynamics of collaboration and coordination among public sectors and governmental bodies in Finland. She pointed out that while the Finnish built asset industry is multifaceted and fragmented, bSF stands out as the central hub for all innovations related to openBIM in the country. Elaborating on the roles and responsibilities within the industry, Lehikoinen stated,

> **"We don't have a set single responsibility, it's fragmented in the industry and public actors are involved too [...] however, the ministry of environment and bSF are the main players for developments of guidelines and standards."**
>
> *Annina Lehikoinen*

In a progressive move, the Finnish government recently introduced a series of legislative acts in 2023. These acts are designed to identify innovation across multiple BIM areas including, building permits, initiatives for climate change, the establishment of BIM digital libraries, archiving, among other vital sectors. This strategic legislative move underlines the government's dedication to tapping into the capabilities of openBIM processes paired with cutting-edge digital technologies. Their primary objective is to facilitate the construction sector's overall efficiency while emphasizing on sustainability. A pivotal aspect of these initiatives is the incorporation of openBIM standards directly into the building permit process. This integration is expected to simplify and expedite the approval stages, minimize bureaucratic red tape, and accelerate the overall project execution timeline.
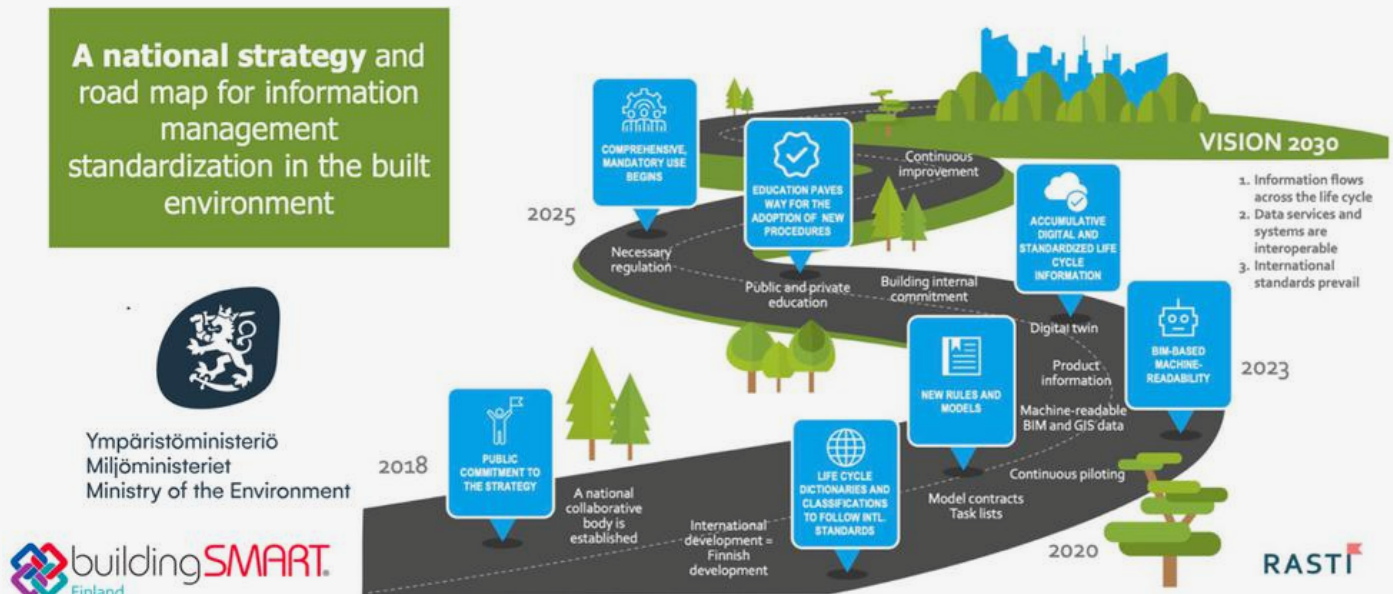
Figure 7. The RASTI project 2018 infographic roadmap (Taken from ICC)

To address the need for a unified approach to open international standards in Finland, the Finnish Ministry of the Environment initiated the RASTI roadmap in 2018 (Figure 7).

This national strategy was primarily introduced due to issues with conflicting standards in information management and the challenges faced by those in the real estate and construction sectors when choosing the best standards. In partnership with bSF and specialists from both building and infrastructure fields, RASTI strives to enhance interoperability by creating a comprehensive information management framework. This framework aims to merge separate actions and existing standards across building, infrastructure, and GIS (Geographic Information System) sectors.

RASTI's structure emphasizes different tiers of enterprise systems essential for information management in constructed spaces. The program's goal for Finnish stakeholders is to form a unified platform at the national level, connecting all relevant parties. This platform is designed to efficiently address the diverse requirements and potential overlaps in different areas. Although hastening the standardization processes is challenging, it's vital for public entities to allocate adequate resources for success. Even though reaching consensus on open standards is time-intensive, their adoption can be sped up. This acceleration is possible by securing solid commitment from key industry participants like designers, contractors, and suppliers to adopt open standards.

The roadmap is still at the state of review by experts and will be in partnership with government agencies and the public sector, bSF has introduced the Built Environment Information Modeling Standardization project, known as RYTV, in 2022. This four-year initiative aims to bring consistency and alignment to the information modeling of Finland's built environment. The program encompasses an extensive array of research and development actions, workshops, case analyses, and directive materials. Figure 8 illustrates the envisioned outcome of RYTV by 2025.

RYTV Project Program Step by Step

Long-term Results

🏢 Quality of life and environment improves, sustainable use of resources

1. **Common BIM requirements for the built environment (RYTV)**
   New and modular RYTV: Formats, terminology, information guidelines, coding and the common guidelines of standardisation

📊 Long lasting products and innovations, dynamic economy

2. **Information standardisation is accessible to everyone**
   Easily accessible instructions, educational programs, vocational courses and self-studying
   Change management, removing obstacles

📈 Improved efficiency and well-being in organisations

3. **Information modelling is the mode of workflow for the entire built environment life cycle**
   Research → development → piloting → reclamation → benefits → tracking

Figure 8. RYTV Project Program Vision 2025 (Taken from bSF)

France

In April 2021, three leading professional groups - FNTP, EGF, and Syntec Ingenierie - collaborated with buildingSMART France (bSFrance) to launch a manifesto titled "openBIM at the service of ecological transition" (Figure 9), a move that underpins quantitative results and the creation of performance indicators.

Figure 9. Introducing openBIM at the service of ecological transition - BIMWorld (April 2021)

This manifesto underscores the importance of openBIM in promoting sustainable and low-carbon approaches in the construction industry. The document is a significant milestone in the organizations' joint mission to integrate digital solutions for an eco-friendly construction industry.

The manifesto presents a long-term strategic plan, stressing the adoption of advanced openBIM technologies for sustainable construction. Supported by national initiatives, these organizations present a unified approach towards eco-conscious construction methods and reducing the sector's carbon impact. Their proposed plan revolves around three core objectives: a unified vision, a collective framework, and a shared roadmap to decarbonize the construction industry by 2050.

The manifesto presents three primary ambitions related to data management and digital innovation in the construction and infrastructure industry:

1 **Common Vision**

2 **Shared Framework**

3 **Common Roadmap**

For the Common Vision, the focus is on ensuring open, accessible, and interoperable data, emphasizing the importance of collaboration. Using openBIM and openGIS is essential to guarantee data accessibility, crucial for effective collaboration across various project stages. The data needs to be sustainable, traceable, and interoperable to ensure smooth interactions and trust among stakeholders. Cloud storage solutions play a significant role in this vision, with a stipulation that such platforms should not be taken over by entities that can't guarantee data sovereignty, neutrality, reversibility, and data efficiency. Additionally, there's a call for improved regulations to safeguard individual and corporate data, intellectual properties, and expertise.

The Shared Framework entails a systematic approach to data organization and exchange. Key elements under this include organizing data around construction objects, with a highlight on the IFC 4.3 standard (ISO 16739) that addresses the digital twin data of a territory. There's also emphasis on standardizing data exchange processes, notably with the ISO 19650 standard, which promotes digitalization in contract processes. The ISO 23386 standard is also mentioned, which empowers industry professionals to specify object properties, a move that underpins quantitative results and the creation of performance indicators.

Lastly, the Common Roadmap seeks to integrate open technology standards and ensure the sustainability of digital assets. This ambition calls for the inclusion of technical guidelines leaning towards openBIM and open Cloud technologies, and the creation of digital twins to be treated as long-term digital assets. This roadmap also seeks to incorporate these standards in rating systems, to make value-based comparisons in aspects such as carbon footprints and the circular economy. Other focuses include optimizing investments and operational costs through digital means and establishing transparent, standardized criteria to prevent competition distortion.

BSFrance underlines the importance of data dictionaries in project management, emphasizing their role in enhancing communication, understanding, and efficient calculations. Data dictionaries bridge the gap between different terminologies used across trades and ensure a uniform digital data representation. This is vital for openBIM processes, where semantics — or the meaningful representation of building information — is key.

Such data is more than just raw info; it's structured, labeled, and ready for intelligent analysis.
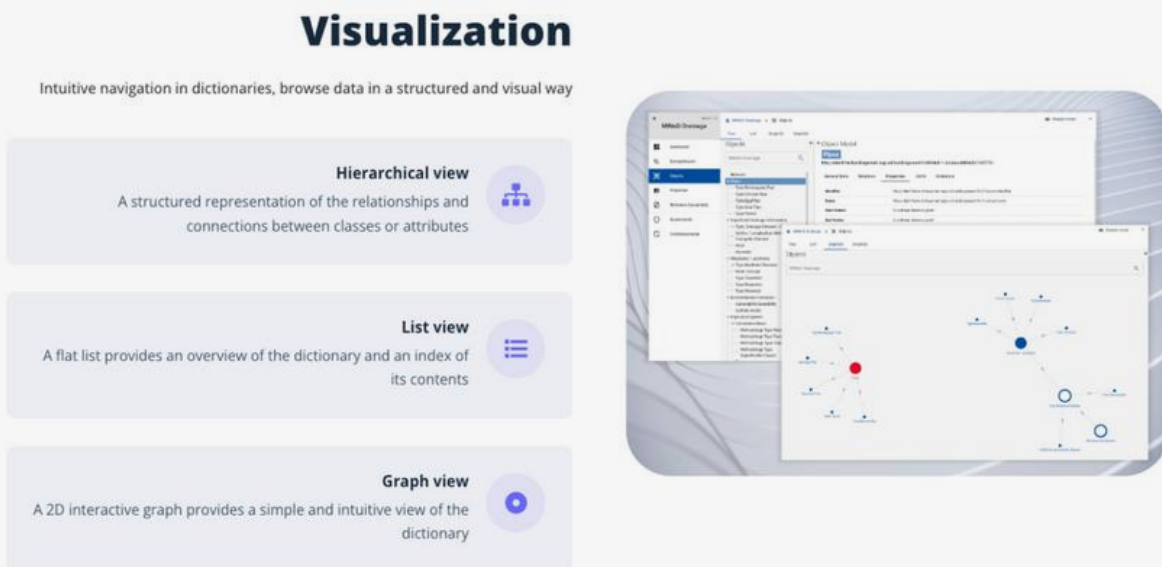
Figure 10. Overview of visualization and workflow of Semantics4BIM developed by BSFrance (Adapted from bSFrance)

France, in a reviewed study, stands out for having developed Semantics4BIM, a web application created by BSFrance and db-Lab (Figure 10). This tool is pivotal in addressing a historical gap: the lack of tools for forming data dictionaries or models, especially among companies in construction or related organizations.

Semantics4BIM's three main strengths are:

- It aids in crafting, overseeing, visualizing, and consolidating data dictionaries and models.
- It's a tool meeting all openBIM standards, emphasizing its importance in the openBIM community.
- Its integration with bsDD ensures data descriptions match the IFC format, promoting global consistency in the AEC sector.

Complying with standards like ISO 23386 and ISO 12006-3, Semantics4BIM provides an open API for software integration. BSFrance notes its usefulness in tracking changes in bsDD, vital for dictionary governance. Users can browse, contributors can modify, and this flexibility enhances dictionary development.

Japan

In Japan, the advancement of openBIM has been deeply intertwined with the rigorous development and adoption of the IFC and the bsDD. The Japan Institute of Architects (JIA) and the buildingSMART Japan (bSJ) chapter have actively promoted IFC standardization, enhancing its compatibility and robustness for the complex needs of Japanese architecture and construction.

Most recently, the Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) has launched a national BIM program, called DX for building and city 2023 (Figure 11), emphasizing on the use of BIM for management of all public project, digital 3D modelling, and the use of real estate ID as the three main components of the program. The goal is to prevent disasters across Japan, reduce CO2 footprints, and support accessibility, as well as the use of drones in Japan.

Following the BIM national program, the MLIT has mandated the use of IFC for building code checks through a subsidiary program (55 million USD total) designed to accelerate the DX process. This initiative places a strong emphasis on supporting small and medium enterprises. It aims to provide them with the necessary hardware and software solutions to leverage openCDE, BIM authoring tools, software licences, and other essential equipment. The goal is to facilitate the adoption of openBIM solutions, with this support commencing in January 2023.

Figure 11. Main components of national BIM program in Japan develop by MLIT (Taken from bSI summit - Norway)

In 2025, IFC submission will be started for building checking process in Japan. Submission of 2D drawings will be still in use, and the use of IFC will be prioritized for automated building code checks. To establish smarter building code checking processes, the use of other open standards and services such as BCF, IDS, and bsDD will also play important roles in this program (Figure 12).
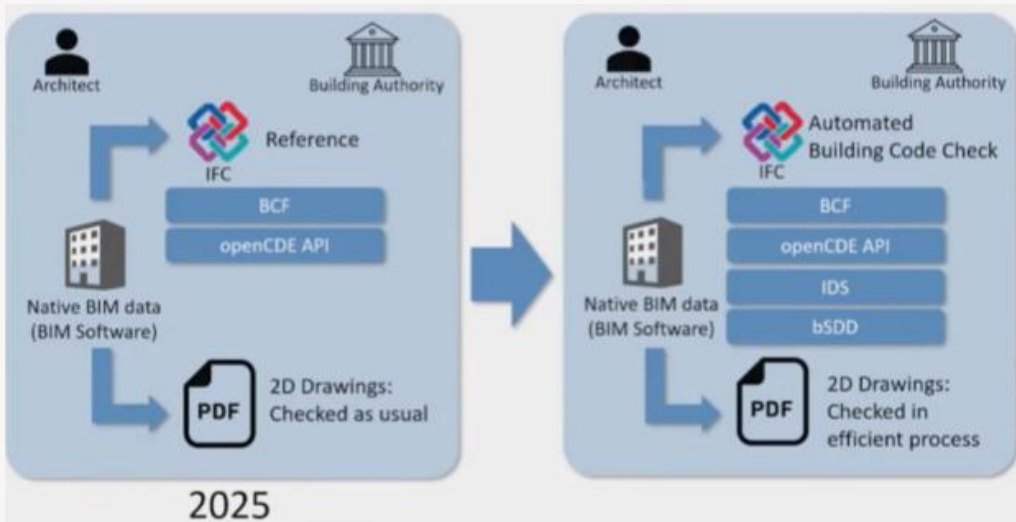
Figure 12. openBIM for automated building checking in Japan (Taken from bSI summit - Norway)

Regarding the digital 3D modeling of cities, the MLIT initiated the development of 3D models for 100 cities starting in 2020.

To integrate BIM with CityGML models, the bSJ, supported by Japanese government, has recently published a comprehensive series of national information delivery manuals (IDM) and the MVD (Version 2.0, 2023). These resources aim to facilitate the delivery of LOD4 city models (Figure 13).
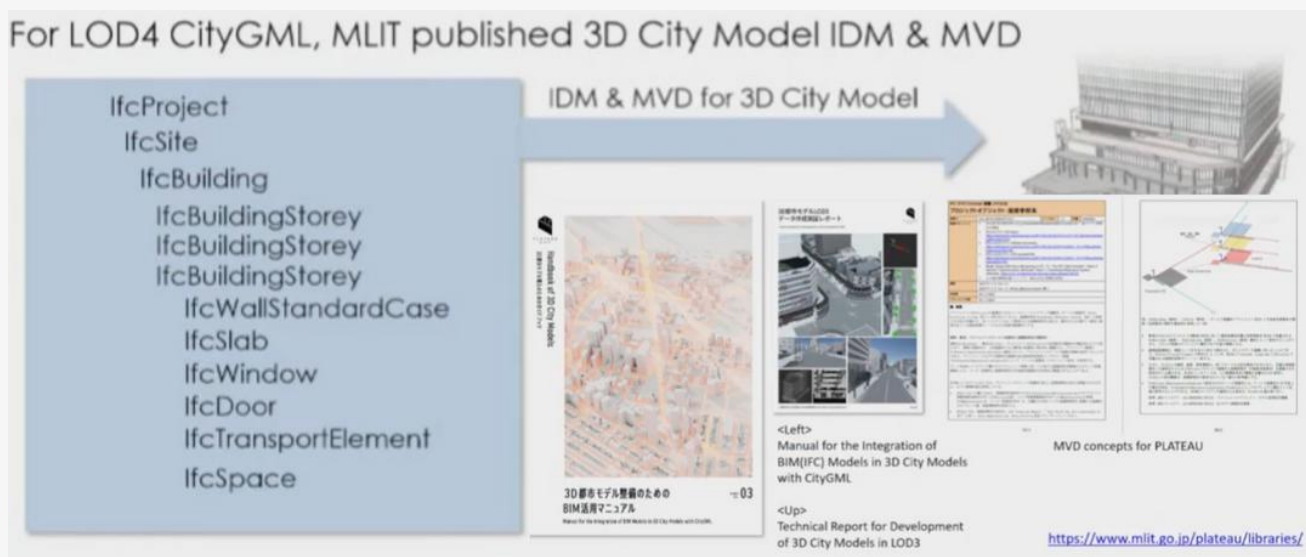
Figure 13. IDM and MVD series published by bSJ to support LOD4 for city models (Taken from bSI summit - Norway)

Norway

Norway is a pioneer in adopting BIM among leading countries. Key organizations such as the Statens vegvesen (Norwegian public roads administration) and Statsbygg (the Norwegian government's building commissioner, real estate advisor, property manger and developer), have been at the forefront of this initiative.

buildingSMART Norway (bSN) has been instrumental in promoting openBIM practices since its inception in 2010, supported by Statsbygg and comprised of members across multiple sectors. Standard Norway (SN) holds the unique authority for national BIM standardization, representing Norway in major international standardization committees.

The Norwegian community is characterized by its inclusivity, trust, and a collective drive for innovation (Figure 14). This societal underpinning, deeply rooted in shared values and a long history of public participation, has undoubtedly been a catalyst in the seamless adoption and integration of BIM across sectors. Steen Sunesen, Project manager at bSN, further explained on the cohesive community of Norway that serves as the bedrock for such initiatives:

> **"In Norway we have a very strong community. We have a quite many members, small and large corporations from various sectors. We have a long relationship with bSI community, very good standing in our national ecosystem of other organizations. bSN is the only organization in Norway that have possibility and potential to solve issues related to openBIM. However, we are working actively to make the bSN attractive for everyone as well, including large contractors, municipality and property owners"**
>
> *Steen Sunesen*

In today's digitized era, data is often referred to as the 'new oil.' For Statsbygg, the data gleaned from openBIM isn't just numbers or figures—it's a goldmine of insights waiting to be explored. By harnessing this data, they can undertake in-depth analysis, which becomes the foundation for making informed decisions. Whether it's fine-tuning a process on a project-specific level (micro) or overhauling strategies that span across multiple projects and timelines (macro), data-driven insights pave the way. Furthermore, it's not just about collecting data but understanding it in the context of the bigger picture. By aligning the nuances of data with the broader goals of the organization, Statsbygg can craft solutions that are tailored, effective, and sustainable. This comprehensive approach ensures that openBIM adoption isn't just about integration, but about taking its potential to the fullest, leading to innovative outcomes and setting new benchmarks in the industry.


Figure 14. bSN community and ecosystem

Figure 15. Digital Building Permit Fronted system in Norway (Taken from TEK)

Inspired by Singapore, Norway has adopted a model-based approach to leverage openBIM standards and processes for digitizing building permit process at the national level.

With the engagement of Statsbygg and other governmental bodies, Norway has gradually paved the way to adopt and test a digital ecosystem for building permits. As depicted in Figure 15, the framework is a well-structured, step-by-step guide aimed at simplifying the submission process for stakeholders. The stages in the framework not only detail the submission of the digital model but also highlight the verification and validation processes, ensuring that the digital models align with Norway's building standards and regulations. Since 2018, Fellestjenester BYGG (Figure 16) has had a module for validating BIM models against information requirements for building applications. The BIM module is based on mvdXML and is not widely used. An update based on IDS is under consideration, but this activity is not prioritized because of lack of market demand. In addition, the Norwegian government has been proactively implementing regulations, offering machine-readable rules, and making APIs available to software companies, programmers, and other industry experts. The aim is to facilitate the creation of automated code-checking tools for construction design. Such an approach (Figure 7) fosters collaboration between the government and the market, ensuring a more efficient implementation of rules and regulations.
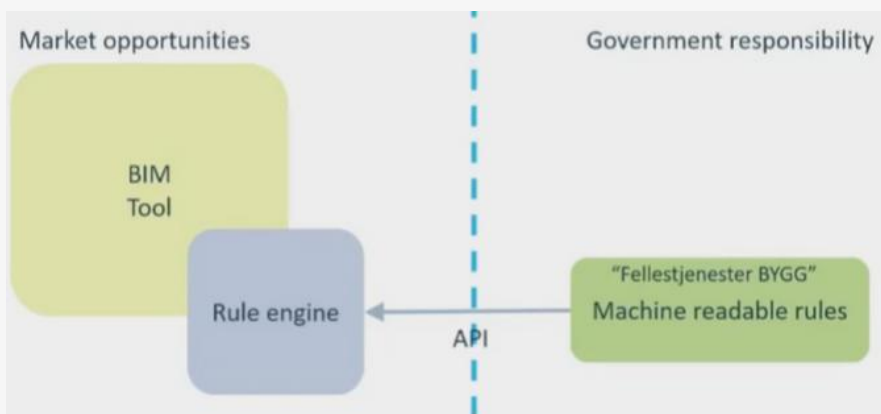
Figure 16. Architecture for automated code checking for construction design

Norway, being a progressive nation in terms of openBIM standardization based on IFC. One of the notable standard series is NS 8360 which has been rooted in the IFC formats, specifically IFC2x3 and IFC4. Additionally, it is structured in alignment with the principles and terminology set out in NS-EN ISO 19650. There is a recognized need for national clarifications, common practices, and additions to ensure its effectiveness and relevance. This standard was curated by the Standards Norway committee, known as SN/K380. Over the years, several standards and guidelines under the NS 8360 series have been introduced:

- NS 8360-1 Model practice, naming, type encoding, and properties: This was revised and updated in 2021 and 2023.
- NS 8360-2 Properties for identification in digital models and marking in construction works + Guideline: This was published in 2021.
- Guideline for NS 8360-series - Norwegian properties: This is currently in production and is expected to be released in 2023.
- NS 8360-3 FM, referencing model to documentation: This is anticipated to be released in 2023.
- NS 8360-4 Energy analysis: There will be a hearing in the fall of 2023.
- NS 8360-5/TS/TR Guidelines: This pertains to the interface between G/S and BIM.

With incorporation of bSI standards like IFC and its alignment with NS-EN ISO 19650 principles, the NS 8360 series serves as a great example for countries seeking to adopt or refine their own BIM standards. Moreover, Norway's continual revisions and updates underscore the importance of adapting to technological and industry shifts. For nations aiming to foster a dynamic and responsive BIM environment, the NS 8360 series offers invaluable insights and a robust template to emulate.

The role of the public sector in advancing openBIM practices is not just passive; they are actively involved, especially through significant funding in research and development and by facilitating the development of openBIM technologies.

Taking Bane NOR as an example, which serves as Norway's counterpart to State Railways, they have taken a pioneering step by introducing the FRE16 BIM requirement documents. These documents provide clarity on the specifications for 3D/4D model results, the structure of these models, the precision required for IFC models, and detailed insights into specific infrastructure model components pertinent to both work and delivery. Furthermore, another significant player in this domain is Nye Veier, a supervisory body overseeing the construction of extensive highway sections. Their influence was particularly felt in 2015 when they persuaded both private and public entities to commit to delivering their upcoming projects using BIM models. As a part of their detailed guidelines, Nye Veier set an ambitious standard by necessitating the application of 'BIM Level 3' for national projects throughout the 2020s. The core elements of this requirement are comprehensive, stipulating that all relevant BIM data must be collated within one master model. Moreover, this information should be stored securely on unified servers that adhere to open file standards, ensuring both the accessibility and security of the data.

Singapore

Singapore's government agencies, such as the Building and Construction Authority (BCA), are collaborating with public sectors to meet the demands of BIM implementation. Falling under the umbrella of the Ministry of National Development, the BCA launches various campaigns to enhance BIM awareness.

This includes organizing workshops, hosting roadshows, and showcasing successful endeavors like the Art Science Museum and housing ventures by the Housing and Development Board. Moreover, the BCA aids industry participants by delivering capacity-building courses via the BCA Academy. This institution provides BIM education to consultants and contractors in the governmental sector.

Singapore is among the limited countries that have explicitly mandated the use of BIM models for national approval submissions. In 2010, the BCA introduced a national BIM roadmap and established funding schemes to promote the active use of BIM in public projects by 2015.

In 2012, the BCA released the BIM guide version 1.0, detailing the potential deliverables, procedures, and professionals associated with BIM in construction. This guide also set standards for BIM exchange formats, emphasizing the use of existing open standards like IFC. In 2021, the Minister of National Development introduced CORENET X, a collaborative initiative led by BCA and other public agencies. This initiative aims to modernize the regulatory framework through the adoption of BIM and its open standards (Figure 17).
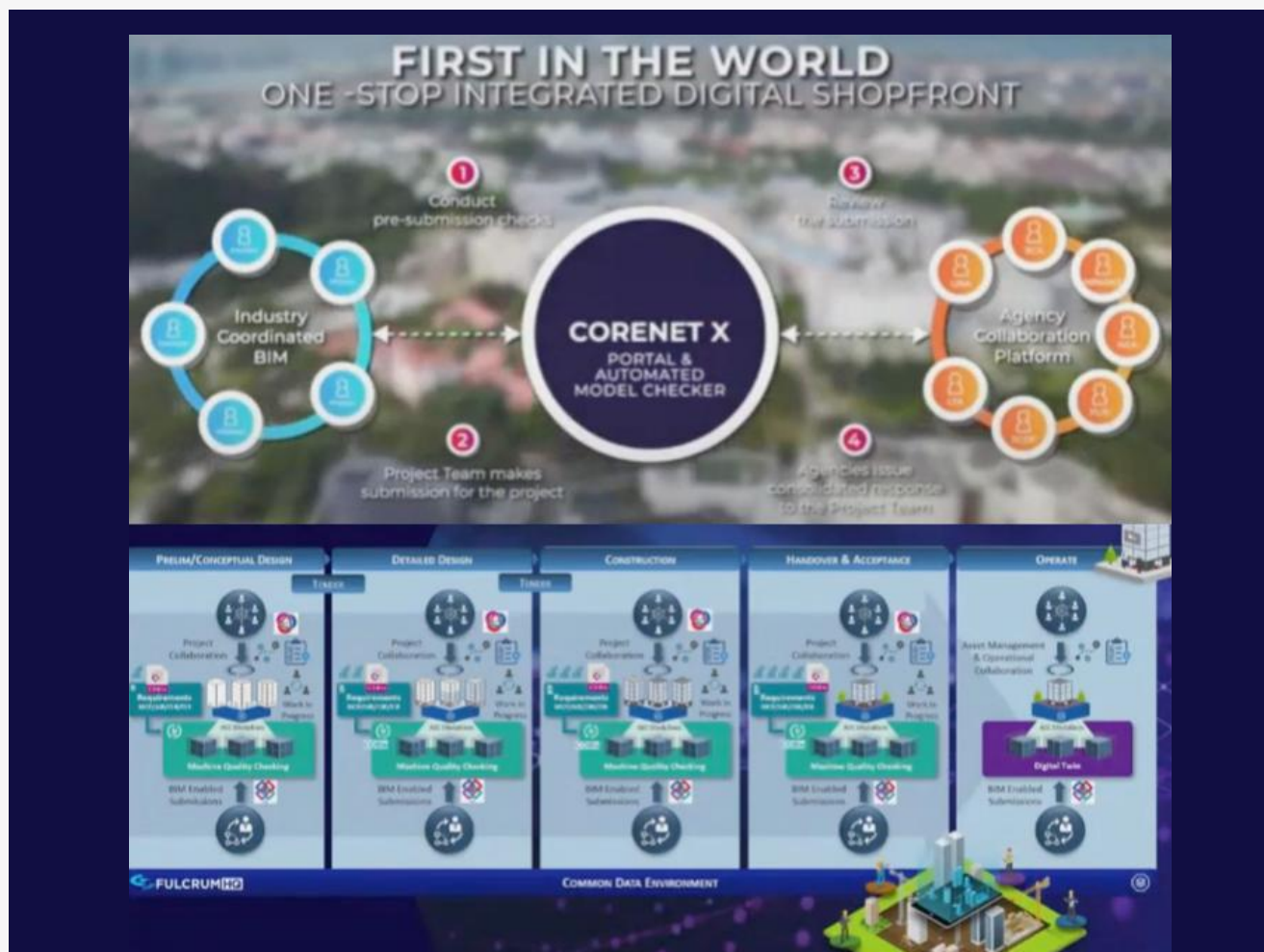
Figure 17. Powering world's first BIM enabled national regulatory platform (Taken from bSI summit Norway)

CORENET X focuses on three main pillars: technological tools, a new BIM-based regulatory approval process, and enhancing the building's change management and capability. The vision of CORENET X is to foster teamwork and streamline operations between the industry and public agencies, reinforcing the Integrated Digital Delivery (IDD) initiative. IDD represents the digital integration of workflows and the connection of stakeholders throughout a construction project's duration and building lifecycle.

Budi Susanto, general manager at LeapThought in Singapore, highlighted the automated checking features of CORENET X across lifecycle stages of an asset. He pointed out the value of CORENET X in maximizing collaboration between parties, stating:

> **"In Singapore, the way design is being approved, it needs to get routed to the seven regulatory authorities (e.g. road regulation, fire safety, water, natural environment, etc.). Designers and engineers must submit their BIM models (IFC format) on CORENET X, let it be pre-checked and processed by machine, including the quality checks, and then routing to the seven authorities for final approval and return the result as a package to the submitter. The seven authorities collaborate together within the same platform such that there is no time and data lost when they're collaborating. CORENET X is built up based on a 3D model viewer which represents the richness of the submitted IFC file and compliance with the national regulatory codes and glossaries. Authorities can easily intervene the model by measuring it or adding comments for revisions. Throughout of the asset's lifecycle, Model data gets upgraded and built up all through the asset completion, and we have machine checks at each stage all through."**
>
> *Budi Susanto*

After the BIM mandate in Singapore, government agencies have prioritized using the openBIM standard (IFC) and its IFC-SG extension as the main schema for BIM submissions. Now, projects with a Gross Floor Area (GFA) exceeding 5,000 sqm must adhere to this standard. Based on the BIM models submitted in the openBIM format, authorities provide written guidelines and approvals. Specifically tailored for Singapore's CORENET X submission, the IFC-SG is an extension of the IFC format (Figure 18). It includes about 3000 rules from various sources to streamline electronic submissions. Each rule mandates the inclusion of certain IFC parameters linked to related objects. For improved information exchange across national BIM repositories and adherence to local regulations, the BCA advises integrating IFC-SG into the BIM validation process in CORENET X and CDEs.
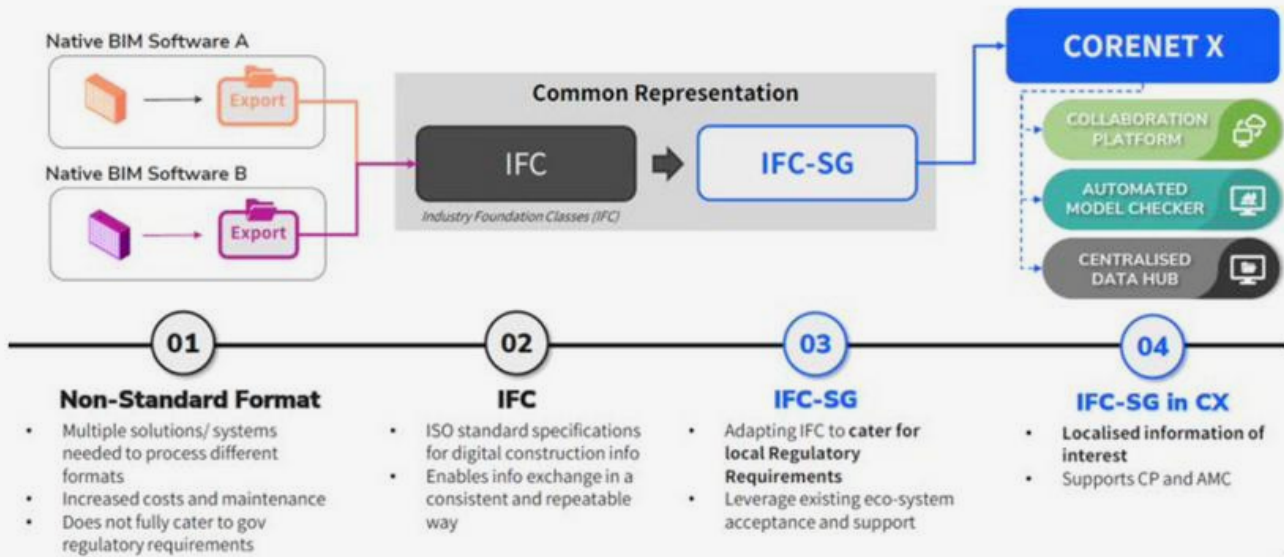
Figure 18. IFC-SG for local context (Taken from ICC)

In general, Singapore's openBIM solutions are rapidly improving, especially since BCA released a thorough set of R&D studies on CORENET X in 2022. BCA and public sectors are keen on disseminating openBIM knowledge via CORENET X. Their commitment is evident in the numerous annual BIM-focused webinars, seminars, and bSI events they participate in. The thriving openBIM ecosystem in Singapore reflects the proactive stance of the government and their commitment to ongoing growth and knowledge exchange in the construction realm. As the sector progresses, **Singapore is poised to maximize openBIM benefits and play a critical role in the global shift towards digitalization of the built asset industry.**

The United Kingdom (UK)

The UK's drive to create a more integrated construction and infrastructure sector has seen it lean towards an openBIM-centric approach, emphasizing open standards and interoperability. One of the foundational steps towards realizing an openBIM environment was the development and adoption of internationally recognized standards.

While the BS1192 and PAS 1192 series laid the initial groundwork, the UK's influential role in the creation of the ISO 19650 series attests to its commitment to global interoperability and open standards. These international standards seek to manage and produce information with BIM in a way that transcends software-specific barriers.

The renaming of the former UK BIM Alliance to Nima signifies more than just a nominal change; it is reflective of a broader shift in strategy and vision. This transformation comes at a time when conversations among professionals in the built environment are no longer confined solely to BIM. Since the endorsement of the original BIM Mandate in 2016, the built environment has seen notable changes, including the inception of the UK BIM Framework and the promotion of Information Management. The discourse is not merely about BIM as a 3D modelling context.

Beyond frameworks and standards, Nima has been a beacon of education.

Through seminars, workshops, and diverse training sessions, it has consistently reached out to stakeholders at various levels of the built environment. The intention has always been clear – to create a broad-based understanding and appreciation of what openBIM solutions stand for and how they can revolutionize the industry. Casey Rutland, vice-chair of Nima and chair of bSUKI, explained that:

> **"Nima will continue to support the development and implementation of the UK BIM Framework together with BSI (British Standards Institution). The main goal is to continue to provide leadership across the UK BIM Framework, providing compelling evidence of the practical, hands-on approach to the framework's adoption, as well as share easy to understand guidance to accelerate the adoption of information management [...] We are present in UK Gov, we connect to professional institutions, we write or contribute to standards, we are present in private sector organisations in numerous domains. Generally, we are where we need to be - we just need more of us!"**
>
> *Casey Rutland*

One of the notable projects in Nima is an information management platform related to UK BIM framework (GIIG) which has been dedicated to improving how information is managed in the construction and asset management industries. Its main goal is to help organizations clearly define what kind of information they need. By doing so, these organizations can more efficiently gather, check, and use data from their partners and suppliers. A crucial aspect of GIIG's approach is making sure this data remains useful over time, even as technology changes. What sets GIIG apart is its team of experts who know the ins and outs of making different information systems work together. They offer specialized advice, ensuring that organizations receive and use high-quality data.

Whether a company owns assets, manages operations, or supplies other businesses, GIIG provides tools and guidance to handle information more effectively. There are multiple areas where GIIG aims to deliver information interoperability and assured valuable data, including:

- **Classification:** it's imperative to have a universally accepted classification structure for information, as this serves as the foundation for interoperability. The UK's BIM Framework advocates for classifying information according to UniClass. A synergistic relationship between classification systems and the GIIG group is instrumental to realize this interoperability goal.

- **The IFC & COBie:** The main ambition here is to equip the industry with hands-on tools and guidelines. The intent is to expedite the acceptance and application of IFC.

- **Information Management Platform (IMP):** It serves as a nexus for various facets, including the stipulation, procurement, delivery, validation, storage, depiction, and utilization of digital asset. The primary objective is to offer tools and assistance for contractors and a broader spectrum of stakeholders who are involved in developing an IMP.

- **Technologies & open standards:** preliminary exploration has been undertaken to identify potential industry-wide solutions related to interoperability. There's a pronounced emphasis on technology vendors. The goal is to craft an Interoperability Code of Practice tailored for these technology providers.

- **Procurement for Interoperability:** the initiative seeks to change procurement processes and contractual frameworks. This is to effectively propagate and elevate the interoperability narrative. There's a targeted effort to collaborate with the UK government to find the best optimal strategies to refine Government Procurement in the context of Interoperability.

- **Standard Information Approach:** This is about finding, checking, and supporting good plans for a consistent way to handle information. It hinges on the most comprehensive evidence of industry best practices, essential facets of interoperability, and is structured to augment outcomes across an asset's lifecycle.

Figure 19. Publications of GIIG (Taken from Nima)

As part of these areas, a wide range of guidelines, glossaries, case studies, and use cases have been published by GIIG as shown in Figure 19.

In essence, the UK's vision towards a more integrated built environment, as showcased by entities like BIM UK Framework, Nima and initiatives like GIIG, underpins a clear message: the future lies in openBIM, interoperability, and an industry-wide collaboration to manage and produce information effectively. The UK, with its focus on developing internationally recognized standards and promoting education and understanding in this sphere, is positioning itself at the forefront of this transition.

This is not merely a matter of technical advancement; it's a paradigm shift in the way the industry perceives the entire life cycle of construction and infrastructure management. The emphasis is not just on the creation or use of tools but on fostering a shared understanding, encouraging standard practices, and building a cohesive network of professionals who can communicate seamlessly.

By ensuring that all stakeholders, from software developers to construction workers and from governmental bodies to private enterprises, are on the same page, the UK is setting open standards for future development. It is a commitment to not only advancing in isolation but to lifting the global industry, heralding a future where boundaries, be they physical or digital, are effortlessly bridged. This sends a clear call to other nations and industry leaders to come together, share knowledge, and work collaboratively to ensure a sustainable, efficient, and integrated built environment for generations to come. Nick Nisbet, director of bSUKI, underscored the urgency, stating:

> **"I would like to suggest buildingSMART chapters should do more with some urgency. We need to get message out to industry that as well as governments acting, individual citizens should take actions. bSI standards and services are the central parts of the sustainability, and industry can adopt them to be more open and address sustainability challenges. Another aspect is the importance of measurement. We may have building models or asset models that need to be measured through openBIM tools before they can be assessed according to sustainability requirements. So, I think we could aim to issue minimum standards for measuring sustainability of building or asset models across lifecycle stages."**
>
> *Nick Nisbet*

The United States (US)

Given that the US boasts one of the most expansive construction markets globally, there's a growing trend towards the adoption of openBIM solutions. Institutions such as the U.S General Service Administration (GSA), National Institute of Building Sciences (NIBS), and the buildingSMART US (bSUSA) chapter, are at the forefront to set the tone in terms of technological innovation, policy direction, and streamlined processes in the sector.

The intricacies of openBIM solutions' development in the US can be as diverse as the stakeholders involved. Jeffery Ouellette, chair of bSUSA, provided clarity on the matter, explaining the wide spectrum of involvement:

> **"It depends on the industry (e.g., commercial buildings, residential, horizontal infrastructure), stakeholder type (e.g., owners [public and private], contractors, design/project delivery professionals, operators, etc.), and level of interest (e.g., national, state, local). In the USA, this includes bS-USA/bSI working with AASHTO (US infrastructure) as well as NIBS to establish various practice and technical standards. Groups like AGC may prefer to focus on their members requirements before engaging NIBS or bSUSA. National Institute of Building Sciences (NIBS) - US BIM Council / National BIM Standard ASTM buildingSMART USA (bS-USA) American Association of State Highway and Transportation Officials (AASHTO) US Dept. of Transportation Federal Highway Administration (FHWA) American Institute of Architects (AIA) BIMForum Design-Build Institute of America (DBIA) […]**
>
> *Jeffery Ouellette*

He continued to detail the interplay of institutions, indicating that the dance of guidelines and mandates often veers towards the voluntary end:

> **"While FHWA might have BIM standards and mandates, AASHTO is really where things get implemented, or not, due to the strength of individual state governments in their own internal affairs (but there is some cooperation between some states). Federal agencies like the GSA also have standards and mandates, but often times these are voluntary and NOT mandatory."**
>
> *Jeffery Ouellette*
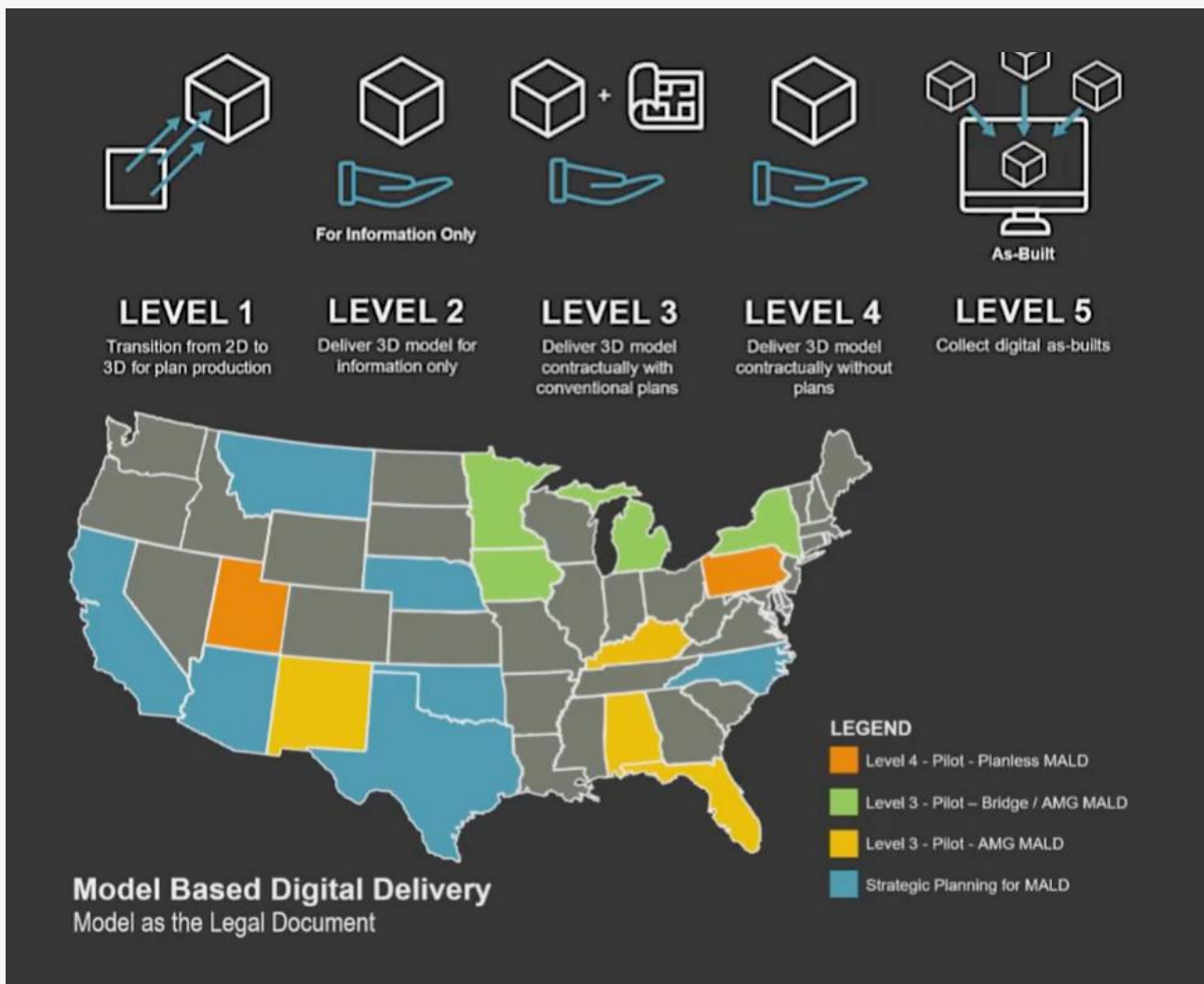
Figure 20. Levels of MALD and its current state in various states of the US (Taken from HDR)

To shift towards paperless digital delivery, the US Departments of Transportation (DOT) in collaboration with American Association of State and Highway and Transportation Official (AASHTO) initiated on a transformative journey starting in 2022.

They introduced the Model as Legal Document (MALD) as an experimental initiative for managing infrastructure projects throughout the nation (Figure 20). With MALD's unique specifications, digital 3D models are merged directly into legal frameworks, thereby by passing the traditionally procedure of toggling between 3D designs, 2D paper blueprints, and actual construction. This progressive step not only supports the decision-making process but also increase the overall efficiency of project delivery. To inform DOT where we are and how to get next levels, the experts in AASHTO JTCEES (Joint Technical Committee on Electronic Engineering Standards) have determined five levels as industry moves to paperless digital delivery.

In the first two levels, users may use BIM authoring tools to automate 2D plans and provide information only to contractors. However, there are many states that are actually moving to levels 3 and 4, where MALD can be found in these levels as digital 3D model is the main contractual deliverable, signed, and sealed by an engineer. At level 5, there is digital built assets which is composed by multiple 3D and 2D digital models across an asset's lifecycle. Figure 2 shows the levels of MALD and its current status across the US, as many states are piloting projects, planless delivery both for roadways and bridge projects.

One of the notable openBIM projects in the US is the transportation pooled fund project, also known as TPF-5(372) BIM roadmap. The project's goal is to offer technical help for using openBIM solutions for bridges and other large structures. This is done under the guidance of AASHTO CBS's software and technology team and another committee, the Transportation Pooled Fund. While BIM is popular in constructing buildings, it's not that common for transportation projects. This is mainly because there aren't set rules on how to use it. To make the most out of BIM for transportation, a detailed plan from AASHTO CBS was conducted. The main vision of AASHTO for this project is to develop a national standard for open exchange of bridge and structure data utilizing IFC. This includes leveraging digital delivery, using MALD, collecting better as-built records, and enhancing collaboration between stakeholders. To incorporate this national effort with bSI standards and services, AASHTO determined to focus on IFC mapping, IDS, and Model View Definitions (MVD) from design to construction stages. While most of the projects in the US are called design-bid-build, meaning the contractors do not get to see files until fully done, it is important to use IDS checkers to validate at bidding and letting processes (Figure 21).
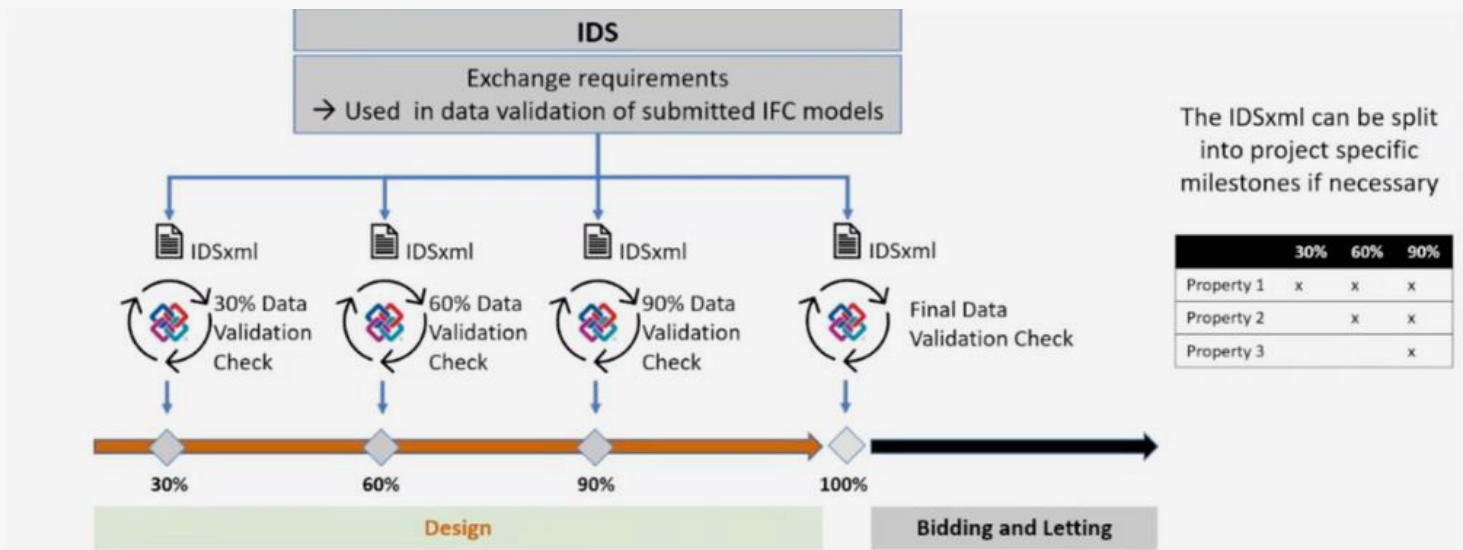
Figure 21. IDS workflow used in the TPF project in the US (Taken from HDR)

To make the most of the bsDD's functionalities, a specialized domain titled "AASHTO bridge" was established. The creation of this domain was not a mere data entry process but a systematic approach that ensured authenticity and precision. Recognizing the significance of a bridge's specific properties and the importance of adhering to national engineering codes, the content was thoroughly vetted by a panel of experienced bridge engineers. This rigorous review, illustrated in Figure 22, aimed to confirm the accuracy and relevance of the information within the domain, aligning it with real-world engineering practices. Understanding the crucial role of consistent terminology in fostering clear communication, AASHTO went a step further. They undertook the ambitious task of compiling a comprehensive transportation glossary. This glossary was not just a collection of terms, but a concerted effort to standardize the language used in the domain. It bridged the potential gaps between varying terminologies, harmonizing terms, synonyms, and even related phrases. By doing so, it ensured that different parties, whether they were engineers, architects, policymakers, or even the public, had a common and reliable reference point. This unified approach aimed at eliminating ambiguities and promoting a more cohesive understanding of the bridge domain and its intricacies.

Figure 22. AASHTO bridge v.1 data dictionary - public example on bSDD service with placeholder information (Taken from HDR)

Key Differences and Similarities of International Best Practices

Based on a review of leading jurisdictions, Table 1 provides a comprehensive summary of the key differences and similarities among them. Drawing from the literature review conducted during phase 1 of this research project, six critical dimensions were identified to facilitate a more nuanced comparison of these jurisdictions:

1 **Governmental Role**
The extent to which the government is involved in pushing openBIM initiatives.

2 **Standardization**
Adoption of open standards, specific standards emphasized, and the creation of national standards.

3 **Technological Innovation**
The emphasis on creating new tools or platforms specifically for openBIM.

4 **Environmental Integration**
How openBIM is used to facilitate environmental and ecological transitions.

5 **Implementations at National Level**
The extent and manner in which a country has implemented openBIM into its national projects, such as infrastructure, public buildings, and other state-sponsored construction endeavors.

6 **Knowledge Source**
Creation of resources, guides, or platforms for education and training.

Table 1

	Governmental Role	Standardization	Technological Innovation	Environmental Integration	Implementation at National Level	Knowledge Sources
🇬🇧	• Regulatory (very low) • Mandate renews • Leadership as client & owner	• ISO19650 series • bSI standards	• Information Management Platform (IMP) • GIIG platform	• GenZero for design of zero-carbon schools • Guides and policies of UK Green Building Council (UKGBC)	• GIIG projects • GenZero project • Sellafield (CDE) • Babcock Major Infrastructure Projects (MIP)	• NIMA guides and services • UK BIM Framework
🇺🇸	• Mandates through federal agencies (GSA). • Moderate support for openBIM in infrastructures	• ISO19650 forwards & annex • US-IDS • CSI • IBD (level of accuracy) • bSI standards • NBIMS-US	• Central facility repository (GOTS) platform	• NIBS-BETEC programs	• TPF-5(372) BIM roadmap • Implementation of MALD for DoT in various US states	• bSI-US openBIM trainings • GSA's BIM hub • NIBS guides
🇳🇴	• Strong support for standards, mandates, regulatory framework	• NS 8360-1 • NS 8360-2 • NS 8360-3 • NS 8360-4 • NS 8360-5 • bSI standards • NS/EN ISO19650	• Simplebim and Pillr platform • BIMQ platform	• Handbook V770 & R760-model basis, to meet UN sustainability goals.	• Bane NOR: Project KIM • National Digital building permit • Statens vegvesen infra projects	• Statsbygg's online database • Resource Bank (by bSN)
🇫🇮	• Strong support for standards, mandates, roadmaps	• bSI standards • ISO19650 series • ISO 191XX (WMS, WFS, GML) • ISO 16739 • ISO 12006	• IFCtoolbox (by Eurostep) • COVE (by YIT) • Model Checkers (e.g.Solibri)	• RYTV program for sustainable use of resources	• RASTI projects • RYTV projects • Open InfraBIM • Vera projects	• bSFinland's WIKI
🇸🇬	• Strong support for standards, mandates, roadmaps	• bSI standards • ISO19650 series • IFC-SG	• Corenet X	• BCA-SkyLab sustainability program • Singapore Green Building Masterplan (SGBMP) • Super Low Energy Programme (SLE)	• BCA BIM implementation roadmap • CORENET X for regulatory checks	• BCA community for education & knowledge sharing
🇫🇷	• Moderate support for certifications • Sustainability regulations	• bSI standards • ISO19650 series	• Semantics4BIM	• Manifesto for openBIM at the service of ecological transition • CSTB 2030 projects	• Projects of Digital Transition Plan (PTNB) • BIM 2022 Plan	• bSFrance online database for guides and policies
🇩🇰	• Moderate support for certifications • Sustainability regulations	• bSI standards • DS ISO19650 series • DS/EN ISO 23386 • DS/EN ISO 23387 • DS/EN ISO 17412	• Molio's product series • LeksiCON • Molio Huset	• ConTech Lab's SME initiatives	• Molio House • ICT program for openBIM	• Molio's BIM services and education
🇦🇺	• Moderate support for national BIM guides and rules	• bSI standards • AS ISO19650 series • OBOS • AS ISO 16739 • BIM-MEPAUS	• NATSPEC BIM Properties Generator • BIM Value tool • BIM benchmarking tool	• Policies & guides of Green Building Council Australia (GBCA) • AS sustainable built environment programs	• Sydney Opera House BIM implementation • Brisbane's Queens Wharf Development	• NATSPEC BIM knowledge hub and trainings
🇯🇵	• Moderate support for national BIM guides and rules	• bSI standards • AS ISO19650 series • OBOS • AS ISO 16739 • BIM-MEPAUS	• National automated regulatory check platform (by 2025)	• National BIM program to mitigate CO2 emissions.	• National DX for building and city planning	• bSJ online database for guides and regulations

# openBIM Opportunities and Interoperability Challenges

buildingSMART Canada (bSC) has emerged as a pivotal entity in the transformative journey of Canada's construction and built asset industry towards digitization. As an organization dedicated to fostering the adoption of openBIM, bSC is not just a proponent of technological innovation; it is a harbinger of a collaborative future shaped by international standards and open, transparent methodologies. The efforts and opportunities in promoting openBIM in Canada can be contextualized within the broader challenges and drivers of openBIM adoption.

bSC recognizes that bridging the knowledge gap between software tools and BIM processes is vital for overcoming these challenges and fully harnessing the potential of openBIM.

Crucial to this bridging is the role of government mandates, which many industry experts have indicated strong support for. Such mandates serve not just as a push factor for BIM adoption, but also as a catalyst for standardization and improved data consistency across the industry. bSC sees this as an opportunity to work with government entities, providing insights and expertise that can shape effective regulatory frameworks. The organization understands that

mandates, while potentially disruptive, especially for smaller businesses, are essential for driving the industry towards unified practices. Therefore, their advocacy includes suggestions for phased implementations and continuous stakeholder engagements to mitigate the negative impacts of these changes.

Moreover, bSC places great emphasis on the leadership role of property owners. Indeed, owners whether in public or private sectors—can be the cornerstone of successful openBIM implementations by fostering a platform-agnostic approach. By focusing on the 'what' rather than the 'how', bSC supports the creation of a more adaptable and innovation-friendly environment. Owner leadership, buttressed by government support in education and resources, can significantly elevate the industry's collective capability to implement and benefit from BIM. Another pivotal aspect is the international standards on BIM, specifically the ISO 19650 series, which sets out the framework for managing information through BIM. bSC recognizes this as a frontier of opportunity. The complexity of the standard's language and its prescriptive nature may pose barriers—challenges that bSC can address through dedicated education and training programs tailored for the Canadian context .
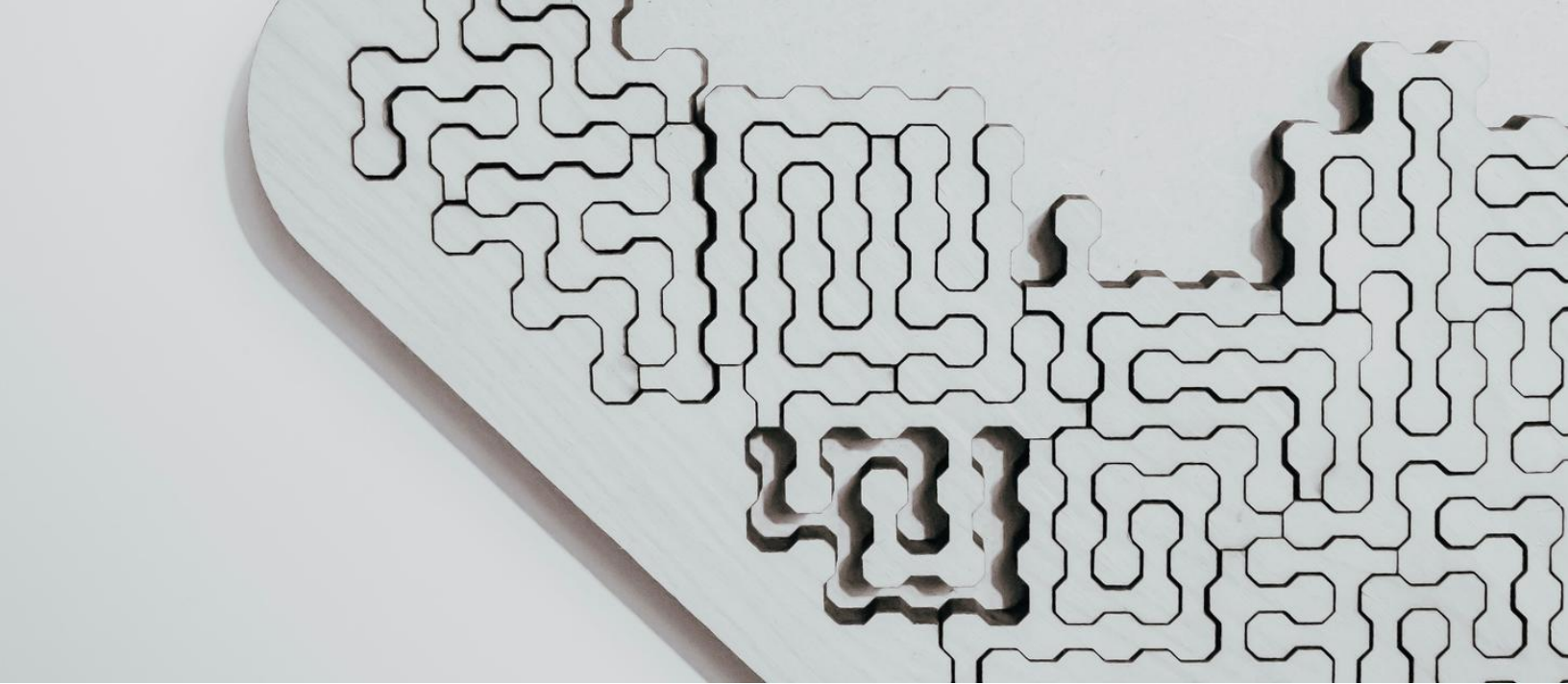
Within the context of these strategic initiatives and the obstacles they present, it's imperative that the large organizations help formulate strategies that support small and medium-sized enterprises during this period of transition. This could involve advocating for supportive measures from the government and establishing forums for collaboration and shared learning. This collaborative approach is particularly pertinent when considering the insights gained from an examination of various leading jurisdictions, which unveiled noteworthy commonalities, trends, and lessons that are especially relevant to Canada. The following sections highlights a final series of openBIM opportunities and interoperability challenges taken from other countries and contextualized for Canada.

Advocacy for Open Standards

Open standards serve as the foundation for the efficient and interoperable practice of digital construction. They are designed to be universally accessible, free from restrictive licenses, and foster collaboration by facilitating a consensus-driven approach. The reviewed jurisdictions are currently advocating for openBIM standards, recognizing the importance of standardized procedures in harnessing the true collaborative potential of the construction industry.

In the UK, the bSUKI has been a front-runner in its support for openBIM through initiatives like the UK BIM Framework and Nima. The UK BIM framework lays out the methodology for implementing BIM according to the ISO 19650 series. The Nima's approach to openBIM is systematic, emphasizing consistent education, defined standards, and clear guidelines. Such an approach not only standardizes procedures but also nurtures an environment where using these standards becomes the norm. Norway's commitment to openBIM is also noteworthy. They have laid significant emphasis on public projects adheriRng to openBIM standards. By doing so, they've elevated the quality and efficiency of public infrastructure projects. The Statsbygg actively promotes openBIM, ensuring that projects adhere to these standards from the onset, ensuring quality and cost-efficiency. Singapore, a bustling hub of modern construction, is yet another shining example. The BCA in Singapore launched the Singapore BIM Guide, which provides detailed insights into the adoption of BIM practices in the city-state. By setting out clear guidelines, the guide promotes the use of open standards, ensuring that the construction sector remains at the forefront of technological innovation.

Drawing inspiration from these nations can provide various opportunities for Canada's own journey.

Advocating the standards is just one aspect; the true essence lies in ensuring their national implementation, fostering an ecosystem where openBIM becomes ingrained in the Canadian industry's DNA. Engaging with stakeholders, facilitating understanding, and building consensus should be the initial steps. By creating platforms for collaboration, learning, and workshops, Canada can develop a shared vision for open standards, similar to the approach seen in the UK.

Government support can significantly catalyze this shift, emphasizing the importance of bodies like buildingSMART Canada (bSC) and National Research Council Canada (NRC) to lead and facilitate these changes. Taking a page from Norway, Canada could consider mandates for openBIM standards in public projects, ensuring quality, transparency, and cost-efficiency. By placing emphasis on openBIM from project inception, a standard of excellence can be set from the outset. Finally, looking at Singapore's structured approach, Canada should aim to provide clear guidelines and resources for openCDE and its implementation in automated building regulatory checks.

Government-led Initiatives

The active involvement of a country's government can be an important force in the widespread adoption and success of openBIM. Governments possess the regulatory and financial clout to incentivize, mandate, and guide the direction of industry practices. Norway and Japan stand out in this regard due to the foresight of their Statsbygg and MLIT. Their push for openBIM isn't just about ticking a box; it's a larger vision for standardizing practices, ensuring sustainability across projects, and ultimately uplifting the nation's entire construction ecosystem. Japan's National BIM program is anchored in openBIM principles, and represent the nation's vision for disaster resilience, integration of GIS and BIM, and reduction of carbon footprint. This government-led integration of openBIM into broader developmental goals showcases how Japan can use it as a tool to address larger challenges, ranging from urbanization to environmental conservation.

Canada, with its robust governmental structures and a vibrant construction sector, can set clear openBIM mandates for public projects,. This would not only elevate the quality and interoperability of public infrastructure but also set a de facto standard for private enterprises. As urban centers in Canada continue to grow, using openBIM for holistic urban planning, focusing on sustainability and resilience, could be immensely beneficial. For instance, a federal mandate could be employed for national infrastructure projects such as highways, railways, or energy projects. Concurrently, provincial, and municipal governments could adopt these standards for schools, hospitals, or community centers. Such a top-down approach can become a normalized standard across all governmental tiers.

Taking a leaf out of Finland's example, a close collaborative approach among government and industry initiatives can lead to an openBIM roadmap that is both rigorous and adaptive to the unique challenges that Canada's construction sector might face.

Collaborative Initiatives

Collaboration at both national and international levels has proven beneficial. The US and Nordic countries, for instance, have initiated joint ventures to bolster openBIM's potential. Such collaborations not only pool resources but also bring together diverse expertise, leading to refined solutions and strategies. These synergies are essential for Canada to learn from, as they can lead to enhanced innovation and shared understanding in its openBIM practices. Moreover, challenges faced in one region can be addressed by solutions tried and tested in another. This reciprocal sharing of experiences and resolutions fast-tracks problem-solving and fosters an environment of continuous improvement. The results are refined strategies, enhanced openBIM standards, and improved tools and methodologies that are the by-products of shared expertise.

Every nation, in its openBIM journey, encounters unique challenges – some arising from its traditional construction practices, and others reflective of its socio-cultural ethos. Yet, many challenges bear a universal character. For instance, France's emphasis on integrating openBIM with ecological transitions or Denmark's strides in standardized terminologies provide rich learning grounds.

For Canada, this underscores the merit of creating collaborative platforms for knowledge exchange. Such platforms can be repositories of case studies, lessons learned, and innovative solutions, ensuring Canada both learns from and contributes to global best practices.

Standardized Terminology and Semantic Consistency

Semantic consistency and standardized terminology are crucial components of the openBIM paradigm, ensuring clear communication and reducing ambiguities in multi-disciplinary construction projects. In a fragmented and complex domain like the built asset industry, the use of common semantics, definitions, and terminologies allow for effective communication and collaboration across various stakeholders. Denmark provides a stellar example in this regard; through the development of the LeksiCON, Molio has focused on achieving consistency in the way construction-related information is shared and understood. The primary goal is to reduce misinterpretations, which could lead to costly errors. By making LeksiCON available openly, they ensure that every participant in the construction process is on the same page, figuratively and literally. In France, bSFrance is promoting Semantic4BIM to ensure that when a project transitions from one phase to another, or one discipline to another, the terminology remains consistent, avoiding potential misunderstandings or errors. In the US, AASHTO has developed a comprehensive transportation glossary which leverage the features of bsDD to harmonize property sets of bridges and tunnels.

A Canadian data dictionary, while being comprehensive, could also be aligned with global standards, ensuring that Canadian firms operating abroad or international firms operating within Canada face minimal friction.

Such a resource wouldn't just be a repository but a reflection of Canada's commitment to ushering its construction sector into a new digital age while maintaining clarity, consistency, and cohesion.

Sustainability via openBIM

Beyond the immediate benefits in the AEC sector, openBIM offers avenues to address larger societal challenges. France's ambitious initiative, as showcased by the manifesto launched in collaboration with bSFrance, places openBIM at the heart of its ecological transition in the construction sector. The manifesto's emphasis on a unified vision, shared framework, and common roadmap stresses the importance of open, accessible, and interoperable data. For Canada, adopting a similar blueprint can lead to a more holistic view of construction projects, thereby ensuring that every phase, from planning to execution, adheres to sustainable practices. The use of openBIM and openGIS in France also ensures that data remains transparent and traceable. Such transparency is pivotal in driving eco-conscious methods by holding all stakeholders accountable, and it can empower Canada to ensure that construction endeavors are not only efficient but also environmentally benign.

Finland's strategy offers a blend of policy-driven and technological initiatives. By introducing openBIM standards directly into the building permit process, Finland has seamlessly merged policy and technology. This move simplifies administrative hurdles and implicitly drives national projects towards sustainability. Every construction endeavor, by virtue of applying open standards, becomes intrinsically aligned with eco-friendly practices. The Finnish government's focus on fostering interoperability, as seen with the RASTI roadmap, also hints at the underlying potential of openBIM. When data is standardized and shared across an openCDE, construction projects can leverage insights from diverse sectors. Such cross-pollination of data can guide Canada in ensuring that its construction projects are both innovative and sustainable.

The move towards sustainable and smart cities in Canada necessitates a departure from siloed decision-making. Urban planners, environmentalists, transportation experts, and technologists must collectively envision urban spaces. openBIM can serve as the unifying ecosystem where diverse stakeholders converge to share insights, analyze data, and collaboratively draft urban blueprints. This collective approach can lead to more informed decisions, ensuring that urban infrastructures are functional, sustainable, adaptable, and in tune with the needs and aspirations of their residents.

Canada's Leap into openBIM Excellence

Overall, Canada stands at the precipice of a transformative era in construction and urban planning, with openBIM offering a blueprint for a sustainable, digital future. Learning from global best practices in the leading jurisdictions, it's evident that adopting open standards fosters collaboration and ensures consistency across projects.

The proactive roles of governments in countries like Norway, Japan, UK, and Singapore demonstrate the power of regulatory mandates in guiding the industry's path into adoption and implementation of openBIM solutions.

Collaborative ventures, both nationally and internationally, can fast-track Canada's digital journey, ensuring shared expertise and mutual growth. Furthermore, the importance of knowledge foundation and semantic consistency, showcased by nations like Denmark and France emphasizes the need for clear communication in multi-disciplinary projects.

With a globally aligned data dictionary, Canada can harmonize classifications, definitions, and terminologies across multiple sectors and industries. This will streamline the exchange of information and foster better collaboration and understanding among professionals from different domains.

Beyond construction efficiencies, openBIM's potential for improving sustainability is crucial at the M&O phase of built assets. Having a centralized openCDE, provides numerous opportunities to trace circularity of information among multiple disciplines, and increase the longevity and efficiency of materials, systems, and strategies that are implemented. In essence, openBIM offers Canada a comprehensive roadmap: one that blends technology, collaboration, and sustainability, guiding the nation towards a promising future in the built environment.

Canada stands at the precipice of a transformative era in construction and urban planning.

Part 2:

Provincial and Territorial Scan of BIM Readiness in Canada

This part of the research project explores the readiness of Canada's provinces and territories to embrace BIM, serving as a foundational resource for the National Research Council (NRC) and other government bodies. The core objectives of this part include assessing BIM adoption, understanding the application of international standards, examining associated challenges, exploring industry sentiment on mandatory BIM adoption in government projects, and defining government leadership expectations for advancing BIM practices.

"The widespread adoption of BIM technologies and practices is currently reshaping the industry"

Approach

This research employed a multi-phased approach of **criteria development, industry engagement, and comprehensive analysis.** The following sub-sections briefly summarize the outcomes from the three phases of this research project.

Criteria Development

The first phase of research involved the development of evaluation criteria that would form the basis for assessing BIM readiness in each province and territory. These criteria were developed through an extensive literature review, expert consultations, and an international analysis of best practices in BIM.

The literature review consisted of understanding the status of BIM practices across the varied provincial and territorial contexts in Canada. It focused on investigating the BIM-related mandates or requirements outlined by the provincial governments across the country. Past surveys conducted by the Canadian Standards Association, Building Transformations, and the Canadian Construction Association in collaboration with KPMG were also reviewed to inform this project. Furthermore, BIM-specific requirements or guidelines outlined by public agencies across the provinces were studied. Subsequently, the following evaluation criteria were developed:

1. BIM Adoption, Implementation, and Maturity: This criterion assessed the extent to which BIM practices have been adopted and integrated into projects within each province and territory. It delved into the sophistication and maturity of BIM usage, considering factors such as project scale, complexity, and technology utilization.

2. ISO 19650 Standards Implementation: As international standards play a pivotal role in shaping BIM practices, the implementation of ISO 19650, a key standard for BIM management, was examined. This criterion explored the adoption and adherence to the ISO 19650 standards across different regions. It highlighted any variations or challenges encountered in its application.

3. Enablers and Barriers: To gain a comprehensive understanding of the BIM landscape, identifying the enablers and barriers faced by industry stakeholders was required to be documented. Subsequently, this criterion encompassed challenges and opportunities related to technology, skills, standards, regulations, and collaboration within the AECOOM sector.

4. Government Mandate: The industry sentiment regarding the mandatory implementation of BIM on government-funded projects was assessed in recognition of the potential influence of government policies—this criterion aimed to gauge industry readiness and acceptance of regulatory measures in the context of BIM adoption.

5. Owner Leadership Expectations: Understanding the pivotal role of asset owners (private and government) in shaping industry practices requires an examination of the expectations of industry stakeholders regarding the leadership that owners and government bodies can provide in guiding a project to digital delivery and advancing BIM practices. This criterion helped elucidate the perceived responsibilities and role owner groups have in fostering BIM adoption.

Industry Engagement

The industry engagement strategy for this research project aimed to capture the current state of BIM readiness in Canada. A purposive sampling framework was used wherein representatives from organizations with the relevant subject matter expertise and understanding of the level of readiness within their organization were invited to participate during the industry engagement period spanning over ten weeks. Purposive sampling is a non-probability sampling technique that relies on the researcher's judgment to select the most suitable participants for the study that are best able to respond to the questions at an organizational level. In this project, a purposive sampling was used to engage key stakeholders who had a comprehensive understanding of BIM implementation in their organizations and are key players in the digital transformation across the AECOOM. Additionally, a wide range of stakeholders from professional associations across Canada were contacted to capture the voices of local and provincial industry partners.

This sampling approach allowed the results to assess the level of readiness and maturity of BIM adoption in the Canadian industry rather than on the opinions or experiences of individual respondents. While the conclusions from this sampling technique cannot be statistically extrapolated to the entire AECOOM sector, the sampling diversity has allowed for a confident report on the current state of the Canadian industry. Furthermore, the industry engagement approach was multifaceted, incorporating surveys, interviews, and workshops to ensure a comprehensive understanding of BIM readiness in the industry sectors across Canada.

Survey

Surveys were chosen as a primary data collection method due to their ability to reach a large audience and collect quantifiable data. The survey was distributed to 140 organizations from various AECOOM disciplines and 118 professional associations and received 59 responses over the ten-week engagement period. The unit of measure for the survey was organizational rather than individual, this is an important distinction, as repeating results from one organization will skew the results toward their level of BIM readiness. The organizational based approach provides a more confident understanding of project delivery, understanding and knowledge from a broader audience both technical and non-technical within the organization. All questions and discussions within the workshops and interviews were representative of the entire organization rather than individual knowledge, this allows the findings of this report to be representative of the wide knowledge range the report is seeking rather than from subject matter experts that would likely result in a seemingly more 'ready' industry. The survey respondents represent over 71,500 individuals in the AECOOM industry from 11 sectors of the industry.

The survey questions were multiple-choice and open-ended, allowing respondents to provide detailed insights where necessary.

The survey encompassed six sections:

Part 1: Demographics
(6 Questions)
This section collected respondents' details, including job roles, company specifics, industry experience, primary service, company size, and the organization's location(s) within Canada.

Part 2: BIM Standards
(13 Questions)
Explored the utilization and familiarity with BIM standards (e.g., ISO 19650) within the organization and related components such as process standards, BIM contracts, information management policies, naming conventions, and QA/QC processes. It also assessed challenges in implementing pre-contract documents and exchanging information requirements.

Part 3: Data Exchange and openBIM
(5 Questions)
Focused on openBIM standards by buildingSMART, the knowledge and usage frequency. It also probed barriers to openBIM adoption, desired support, and success stories in implementation.

Part 4: Education/Upskilling
(5 Questions)
Assessed opinions on the AECOOM sector's software and technology options, digital transformation readiness, sources for upskilling, graduate preparedness, and essential resources for successful BIM implementation within their organization.

Part 5: Government BIM Mandate
(6 Questions)
Explored digital project deliverables, awareness of potential government openBIM mandates for permits and owner submissions, global BIM mandates, organizational readiness, and expectations from the government regarding BIM leadership.

Part 6: BIM Use & Challenges
(19 Questions)
Evaluated BIM maturity in completed projects across the organization, usage of BIM Execution Plans, practices for BEP development, disclaimers when sharing digital models, expertise in various BIM applications, and challenges encountered in BIM projects, including LOI/LOD implementation difficulties.

Workshops

The workshops were virtual meetings using a collaborative whiteboard to structure the workshop sessions. The workshops were designed to foster an open dialogue and collaborative problem-solving among participants. A total of five workshops with representatives from thirteen organizations were organized over the ten-week engagement period.

The workshops brought together professionals from across the industry to discuss their organization's experiences with BIM, share best practices, and brainstorm solutions to common challenges. The interactive nature of the workshops added a qualitative depth to the data collected. In these one-hour-long workshops, industry professionals shared valuable insights, providing a comprehensive view of BIM adoption, challenges, and government involvement in the construction sector.

The **key themes** covered during the workshop included:

Experience with BIM Projects: Participants discussed the BIM project experiences of their organizations and highlighted enablers and obstacles for BIM adoption on projects.

BIM specialty use cases: Insights were shared on BIM use cases such as sustainability analysis, code compliance, owner requirements, design for manufacturing, digital twin creation, and product standardization.

Experience with ISO 19650: Discussions covered experiences with ISO 19650, its benefits, challenges, and the value of naming conventions like MasterFormat, Uniformat, and Uniclass.

Data Interoperability and Standards: This theme explored data interoperability, common use cases, challenges, data formats, and experiences with openBIM (IFC) on projects within their organization.

Government Mandates and BIM Implementation: Conversations revolved around government mandates for BIM, opinions on ISO and openBIM, using models as legal documents, impacts on industry practices, and international experiences.

Owner Leadership: The workshop addressed the owner's role in supporting BIM, focusing on short and long-term expectations and required resources.

Interviews

To supplement the survey data and gain a deeper understanding of the nuances of BIM implementation, one-on-one interviews were also conducted. A total of four interviews were conducted over the ten-week engagement period. These interviews targeted professionals from various AECOOM sectors, including architects, engineers, construction managers, and facility managers.

The semi-structured interview format allowed for flexibility, enabling the exploration of specific topics in greater detail based on the interviewees' experiences implementing BIM processes and technologies in their respective industry sectors.

The one-hour interviews focused on similar workshop themes but were designed to delve deeper into the insights captured from the survey and workshop data. Similar to the workshops, the interviews were also virtual meetings using a collaborative whiteboard for structuring the interviews.

Comprehensive Analysis

A comprehensive analysis of BIM's current state and future trends in the Canadian AECOOM sector was conducted following the extensive stakeholder engagement activities. The data collected from the survey, workshops, and interviews was analyzed and synthesized to understand the benefits, challenges, drivers, and barriers of BIM adoption in Canada. The results from the analysis are outlined in the upcoming sections of the report following the outline of the project objectives and evaluation criteria developed.

Finally, this report is a qualitative analysis, its goal has been to bring forward themes and a qualitative understanding of the industry in their digital transformation and BIM readiness.

1. BIM Adoption, Implementation, and Maturity: The extent to which BIM practices have been adopted and integrated into projects, along with the maturity of BIM usage.

2. ISO 19650 Standards Implementation: Adoption and adherence to ISO 19650 across different organizations and highlighting any variations or challenges encountered in its application.

3. Challenges and Barriers: Outlining challenges related to technology, skills, standards, regulations, and collaboration within the AECOOM sector.

4. Mandatory BIM Implementation: The industry sentiment regarding the mandatory implementation of BIM on government-funded projects.

5. Government Leadership Expectations: Responsibilities and roles of the government in fostering BIM adoption.
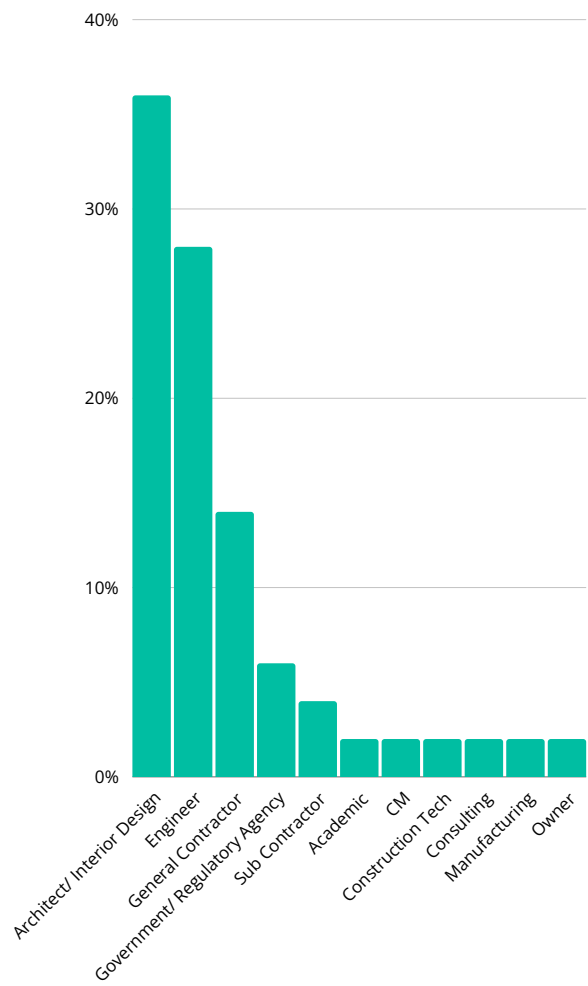
Participants

The participants were very experienced in their respective industry sector; 45% had between 11-20 years of experience, and a significant segment, 21%, boasted extensive experience of 25 years or more, showcasing a seasoned professional presence in the industry to speak to the digital transformation covered in this report. In contrast, those with 0-3 years of experience represent a smaller proportion of respondents.

The participants covered a diverse range of organizations, with 36% of respondents representing the architecture and interior design sector. Engineering services closely followed, making up 28% of the respondent organizations. General contracting services were at 14%.

Academic institutions, associations, and consulting firms account for a collective 8% of respondents, highlighting the diversity of services within the industry. Representation from government and regulatory agencies, manufacturing, owners, and sub-contractors occupied a small share of this report.
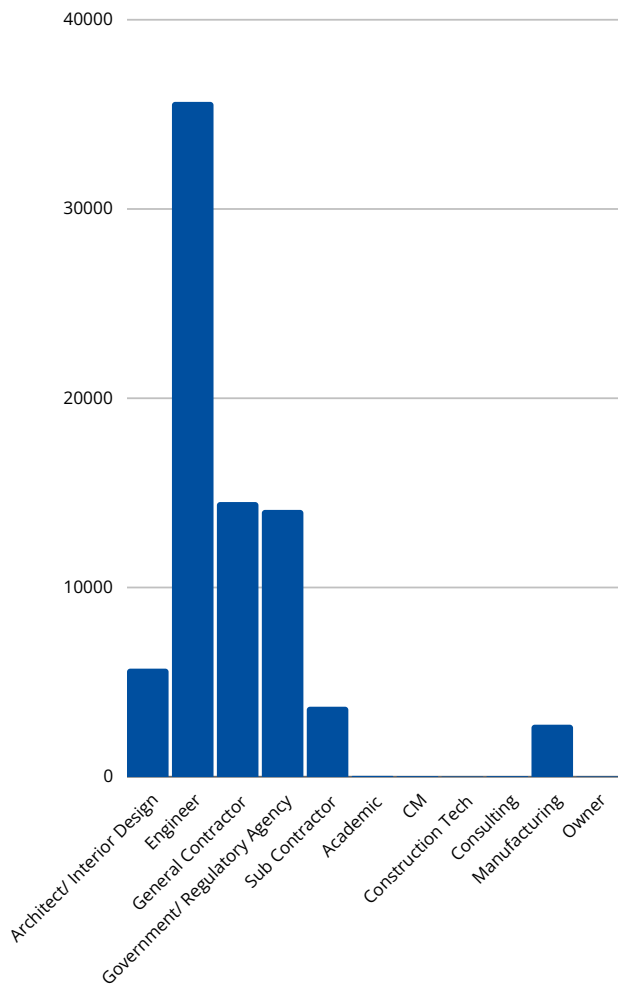
**Figure 23: Number of People Represented within the organization**

Figure 24: Participant Organizations by Discipline

Geographically, the survey demonstrated a broad national reach within the industry landscape and provided insights into the distribution of organizations across Canada's provinces and territories. Many organizations operated and completed projects across multiple provinces.

Ontario was the predominant location, with 74% of organizations operating there. Alberta, British Columbia, and Quebec, with 49%, 43%, and 36%, respectively, showcasing substantial industry presence in these regions.

Manitoba, Nova Scotia, and Saskatchewan each accounted for 30%, 17%, and 5% of organizations, contributing to regional diversity. The other provinces and territories, including New Brunswick, Newfoundland and Labrador, Northwest Territories, Nunavut, Prince Edward Island, and Yukon, collectively represented small shares of the organizations.
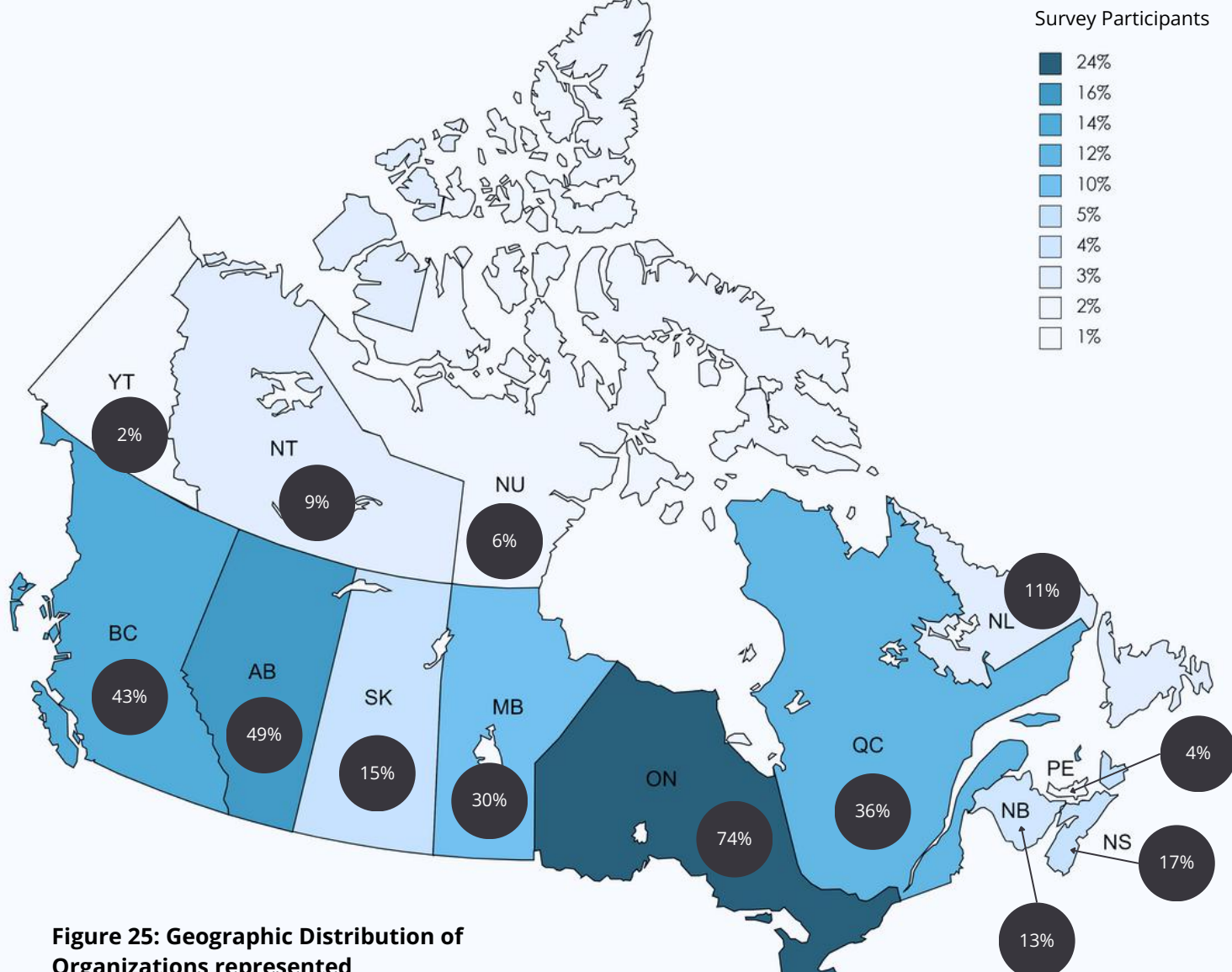
Figure 25: Geographic Distribution of Organizations represented

BIM Adoption, Implementation and Maturity

Adoption

This section outlines the extent to which Building Information Modeling (BIM) has been embraced within organizations or projects. It investigates **whether BIM has been implemented** and, if so, how extensively.

Key indicators of BIM adoption include the percentage of projects within the organization have implemented BIM, the requirement of BIM processes in contracts, and the development and use of BIM Execution Plans.

Digital Requirements and Deliverables

Push towards Digital:
Digital technologies are gaining traction nationwide, as evidenced by the increasing use of digital deliverables besides PDFs, such as BIM files (native or open format), CAD files for design drawings, xls/csv files for reports and schedules, and specialized formats for specific types of analysis or modelling such as computational files.

For over 76% of their projects, 30% of organizations have adopted this approach. Another 36% of organizations use digital deliverables for 25-75% of their projects, depending on the project scope and goals. However, 30% of organizations still rely on digital deliverables for less than 25% of their projects, indicating a potential for further digital integration.
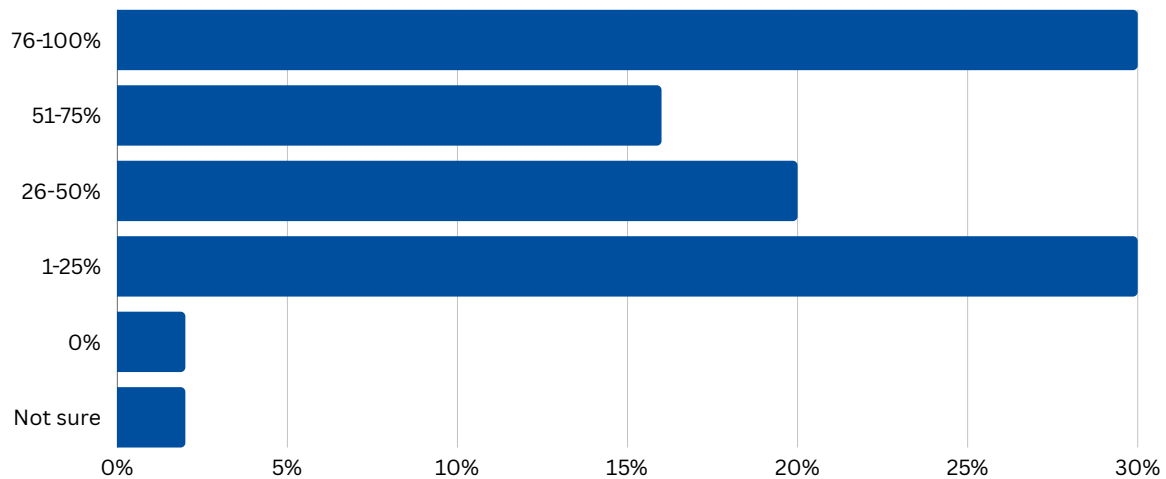
Figure 26: Percentage of projects with digital deliverables besides PDFs

Diverse Expectations:

The contractual requirements for digital deliverables vary across projects and organizations. While 61% of organizations reported that digital deliverables were required for 1-25% of their projects, only 14% of organizations reported that digital deliverables were required for 75-100% of their projects. This suggests a diversity in the expectations and standards for digital deliverables.
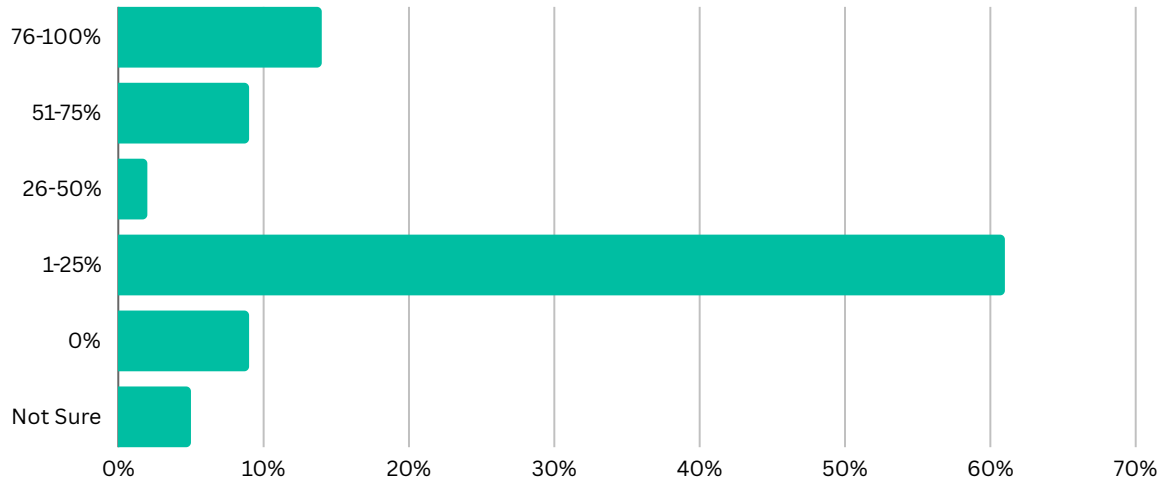
Figure 27: Percentage of projects contractually requiring digital deliverables

Varying BIM Requirements:

While the industry increasingly adopts BIM, the contractual requirements for BIM processes are not consistent across projects and organizations. The survey data revealed that most organizations (52%) were required to implement BIM processes for 1-25% of their projects, suggesting a growing recognition of the value of BIM for design and construction, but also a need for improvement and standardization. Only 9% of organizations were required to implement BIM processes for 76-100% of their projects, while 2% were not required at all.
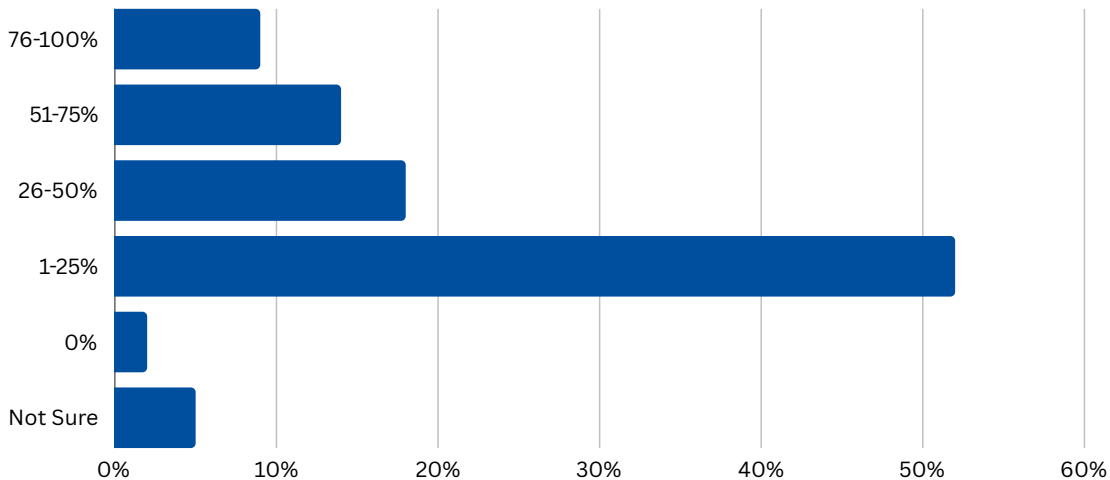
Figure 28: Percentage of projects with contractual requirements for BIM processes

BIM Execution Plan

A BIM Execution Plan (BEP) is a comprehensive planning document that helps project participants move forward with clear roles and expectations, collaboratively. It is a framework for strategically implementing BIM using consensus-built best practices, standards, and protocols. The BEP should be continuously used and updated throughout design and construction. The key components of a successful BEP include:

- **Clearly defined roles and responsibilities** of each team and organization

- **Strategic planning**, BIM scope definitions, and defined key deliverables

- **Project milestones** and a realistic timeline

- **Project goals/BIM objectives**

- **Model quality control procedures**

- **Project reference information**, including key project contacts

A BEP is an essential element to create before beginning any construction project, especially for large or complex ones with many collaborators. A BEP keeps all collaborators in sync through clear roles, responsibilities, and real-time communication while ensuring construction stays on track. A thorough BEP is a powerful project accountability tool that keeps work moving forward throughout the various planning and construction phases.

The respondents suggested that the use and update of BEP varied across the BIM-enabled projects. Most organizations (43%) always used BEP but only occasionally updated it. Only 15% always used and regularly updated BEP, indicating a high level of BIM maturity. On the other hand, 2% always used BEP but never updated it, suggesting a lack of using BEP as a living document.
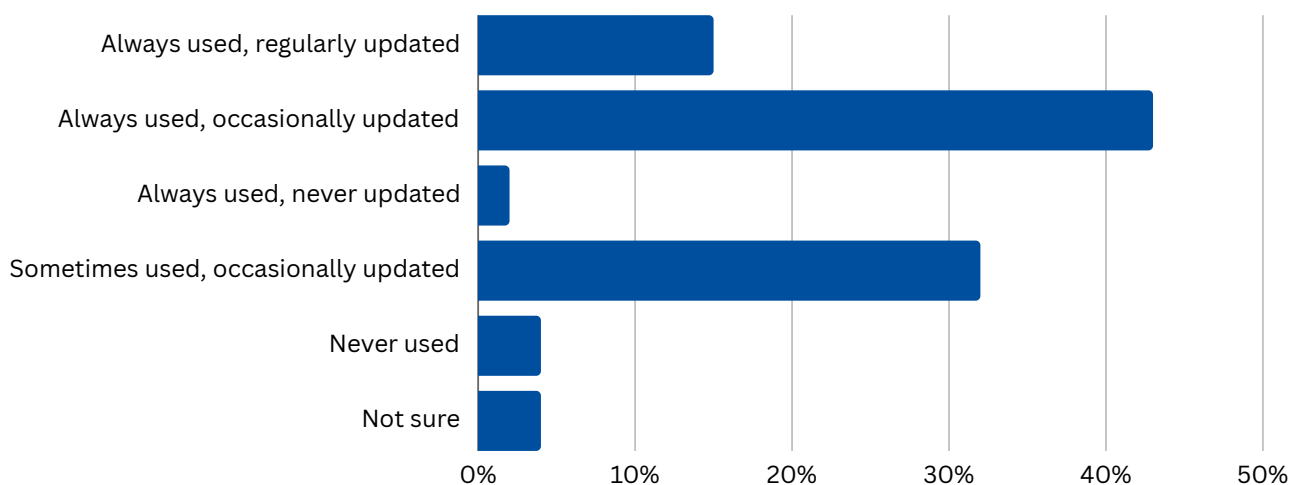
**Figure 29: Usage and update frequency of BEP on BIM-enabled projects**

Implementation

This section delves into integrating BIM into an organization's operations or a project's workflows. It examines **how BIM is used in practice** and highlights the processes and expertise involved in using it for different purposes.

Key indicators of BIM implementation include the approach to the development of BIM Execution Plan (BEP) and the application of BIM for various purposes, such as design authoring, design analysis, visualization, design coordination, 4D simulations, quantity takeoffs, and cost estimations and other specialty use cases where BIM has the potential to be used.

BIM Execution Plan Development

The development of BEP varied across the BIM-enabled projects. Most organizations (41%) developed BEP collaboratively with the project team, indicating a high level of integration and communication. Another 30% developed BEP by the architect and reviewed and approved by the owner's BIM team, suggesting a more centralized and controlled approach.

Only 16% developed BEP in-house by the owner's BIM team, indicating a strong ownership and leadership in BIM implementation. On the other hand, 7% developed BEP by the contractor and reviewed and approved by the owner's BIM team, suggesting a more delegated and reactive approach. Finally, 7% were unsure or used an external BIM consultant to develop BEP, indicating a lack of internal expertise or resources but initiative to outsource the needed expertise.
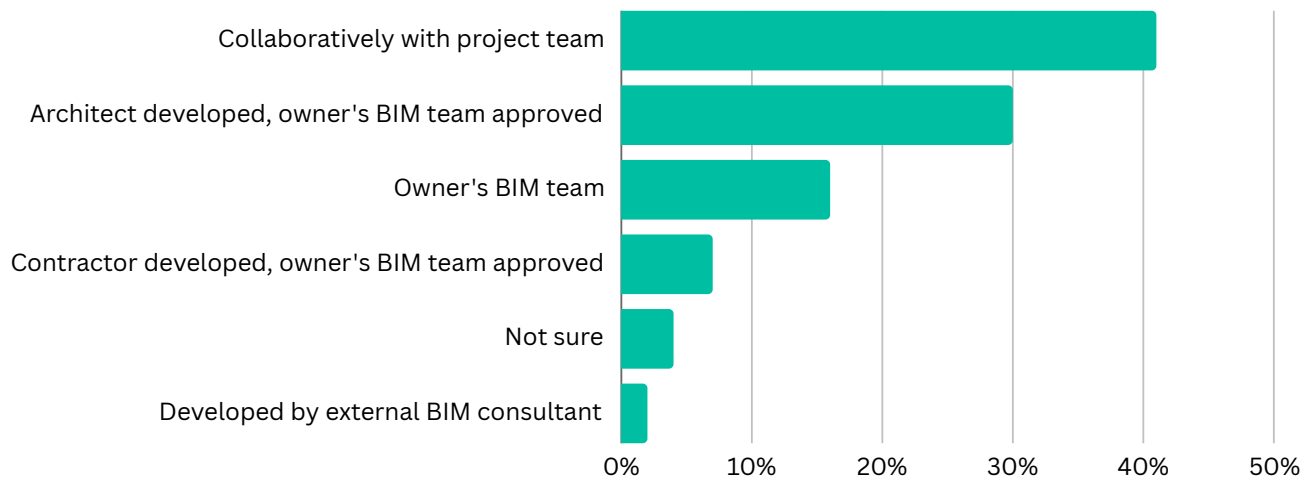
Figure 30: Approach to developing BEP for majority of projects

Design and Engineering Expertise

Design Authoring:

Design authoring using BIM is the process of creating and managing the digital representation of a development's design using BIM software. Most organizations (32%) were experts in using BIM for design authoring and having the ability to guide others.

Only 16% were proficient and confident in reviewing and authorizing the BIM model. Another 20% were competent, suggesting they understood the authoring process well but needed support. On the other hand, 16% had limited expertise, requiring significant support.
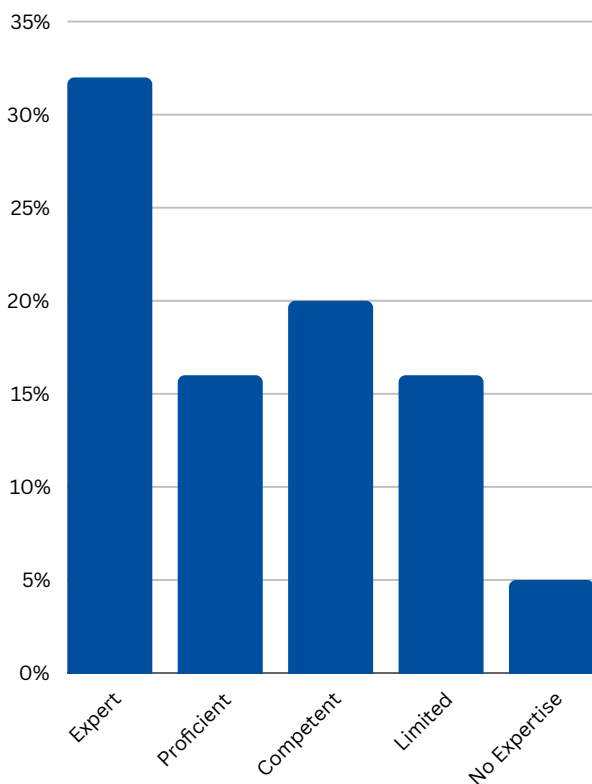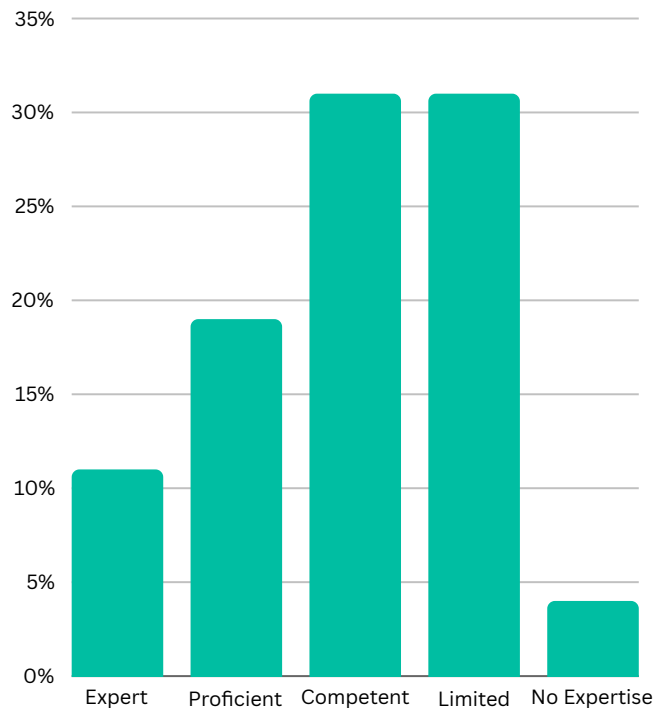

Figure 31: Expertise in design authoring

Figure 32: : Expertise in design analysis

Design Analysis:

BIM software can be used to perform various types of structural, mechanical, and energy analysis. Most organizations (27%) had limited expertise in using BIM for design analysis. Another 27% were competent, showcasing a reasonable understanding of multiple analysis processes.

Only 16% were proficient, representing an in-depth knowledge of complex analysis processes. On the other hand, 14% were experts, suggesting they could create specialized analysis tools and workflows using BIM.
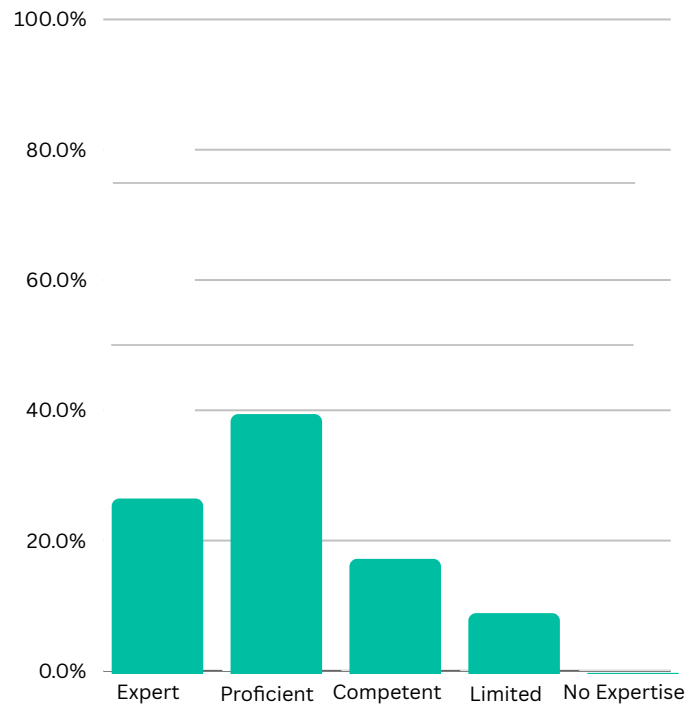
Visualization and Communication Expertise

Designers and Engineers:
BIM can be used for visualization and design communication by creating and sharing graphical representations of a design, such as drawings, renderings, animations, and walkthroughs. It helps with communicating design intent and engaging with clients and stakeholders.

Most organizations (83%) are experts in using BIM for visualization and design communication and have extensively used BIM for this purpose. The remaining 17% are proficient and regularly used BIM for this purpose and understand its capabilities well.
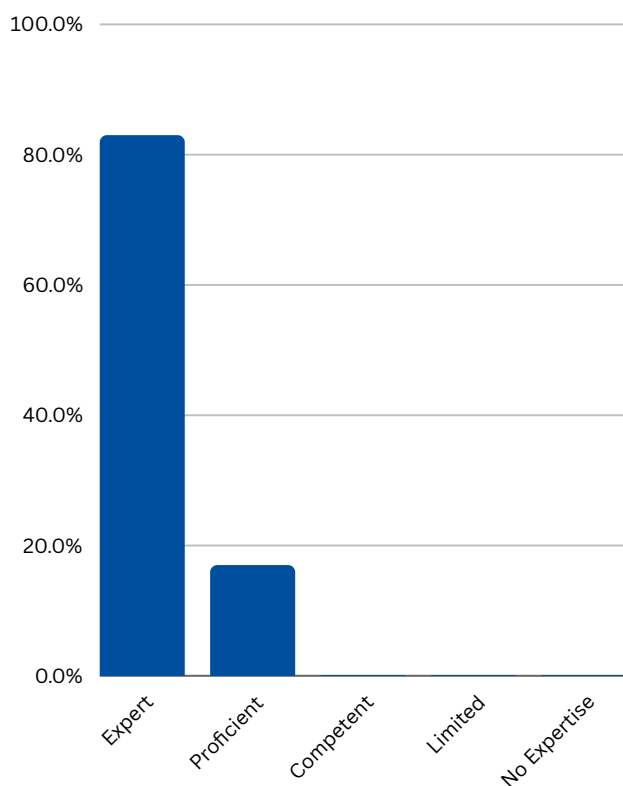
Figure 33: Expertise among designers and engineers

Figure 34: Expertise among GCs and subcontractors

General Contractors (GCs) and Subcontractors:
GCs and subcontractor organizations utilize BIM to understand and execute the design intent, coordinate their work, and communicate their progress and issues. Most (43%) reported that they were proficient in using BIM for visualization and design communication and regularly used BIM.

Another 29% reported being experts and extensively using BIM with a deep understanding of its capabilities. On the other hand, 10% of them reported occasionally using BIM, indicating a variation in the confidence and competence among the GCs and subcontractors.

Coordination, Sequencing, and Estimation Expertise

Design Coordination:

GCs and subcontractor organizations utilize BIM to detect and resolve clashes, assign and track tasks, and manage issues among the design disciplines.

Most (87%) respondents had extensive experience using BIM for this purpose and could guide others. The remaining 13% were proficient and confident in coordinating designs using BIM.
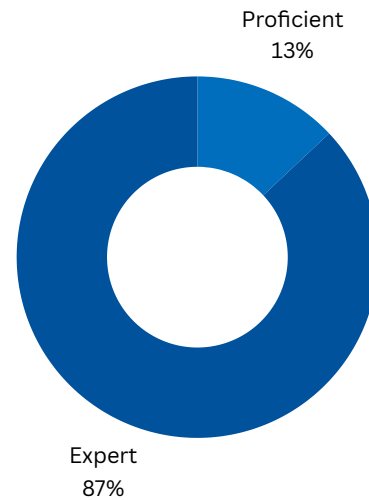
Figure 36: Expertise in design coordination using BIM
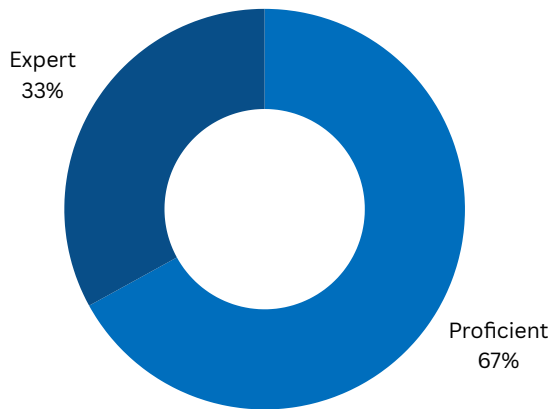
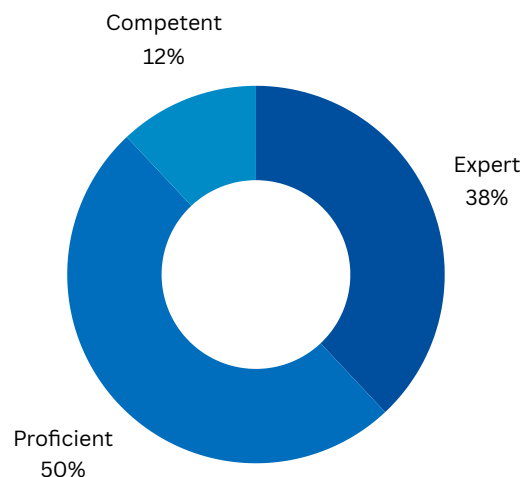**Figure 35: Expertise in 4D simulations using BIM**

4D Simulations:

GCs and subcontractor organizations utilize BIM to create and visualize the construction schedule, sequence, and site utilization of a project called 4D simulations.

Respondents exhibited high confidence and competence in using BIM for 4D simulations, with 33% having extensive experience and capable of guiding others. At the same time, the remaining 67% were highly confident in their ability to create and use 4D simulations.

Quantity Takeoffs and Cost Estimation:

GCs and subcontractor organizations utilize BIM to extract and calculate the quantities and costs of a project's materials, labour, and equipment.

Data showed that most organizations (50%) were proficient in this skill, while 38% were experts. Only 16% were competent, and none were limited or not applicable. This indicates high confidence and competence in using BIM for quantity takeoffs and cost estimations.

Figure 37: Expertise in quantity takeoffs and cost estimations using BIM

Speciality Use Cases

In terms of using BIM for specialty use cases, the respondents shared the following views:

Sustainability and Code Compliance: BIM plays a significant role in sustainability analysis and code compliance, but challenges include data exchange difficulties and code compliance verification outside the BIM environment.

Design for Manufacturing: Design for Manufacturing (DfM) finds application in prefab housing and offsite construction, with potential but hindered by limited prefab experience and the need for standardization.

Digital Twins: The digital twin concept is gaining momentum, focusing on data, information containers, and integration with facility management systems.

Product Standardization and Owner Requirements: Challenges in product standardization arise from owner preferences, suggesting the need for standardizing information and refining owner needs.

Maturity

This section **measures the sophistication** of an organization and theirs projects' use of BIM. It considers factors like the level of collaboration, integration with other systems, and ability to leverage BIM for different purposes.

The maturity of BIM usage is assessed through indicators such as approaches to managing CAD and 3D workflows, use of advanced technologies for collaboration and integration, and knowledge and frequency of use of data exchange and international BIM standards.
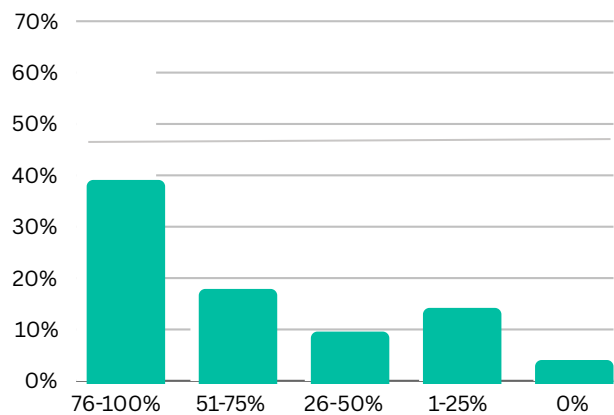
Workflow Management

2D CAD Workflows:
CAD workflow management involves using software to organize and share CAD files and data. Encouragingly, 68% of the organizations used structured workflows with some standardization of information on more than 75% of their completed projects. Only 12% of the organizations had worked with unstructured workflows on less than 50% of their projects. This indicates that the organizations value the benefits of CAD workflow management, such as improved collaboration, quality, and efficiency.
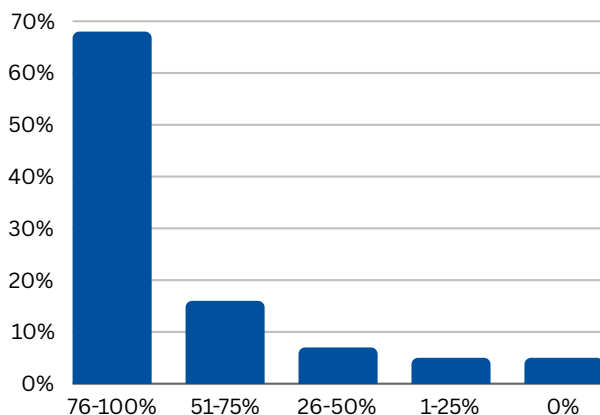
Figure 38: Percentage of CAD workflow management among completed projects

Figure 39: Percentage of 3D workflow management among completed projects

3D Workflows:
Workflow management in a 3D environment uses electronic data sharing through a common file format to collaborate model information with project team members. Data analysis suggests that 43% of the organizations used managed 3D environments on more than 75% of their completed projects. In contrast, only 5% of the organizations had completed projects without a managed 3D environment. It indicates that the organizations recognize the benefits of 3D environment management, such as improved visualization, coordination, and quality.

Digital Collaboration

Cloud platforms and similar technologies can help create digital collaborative environments by integrating model and project information from various stakeholders. Such integrated and collaborative models can enable stakeholders to reduce communication latency and increase overall information access.

Based on analysis, 30% of the organizations reported to have used an integrated and collaborative model for more than 75% of their completed projects. In contrast, 7% of the organizations reported never using an integrated and collaborative model on their completed projects. This suggests that the organizations have room for improvement in adopting and implementing these technologies to enhance project performance and outcomes.
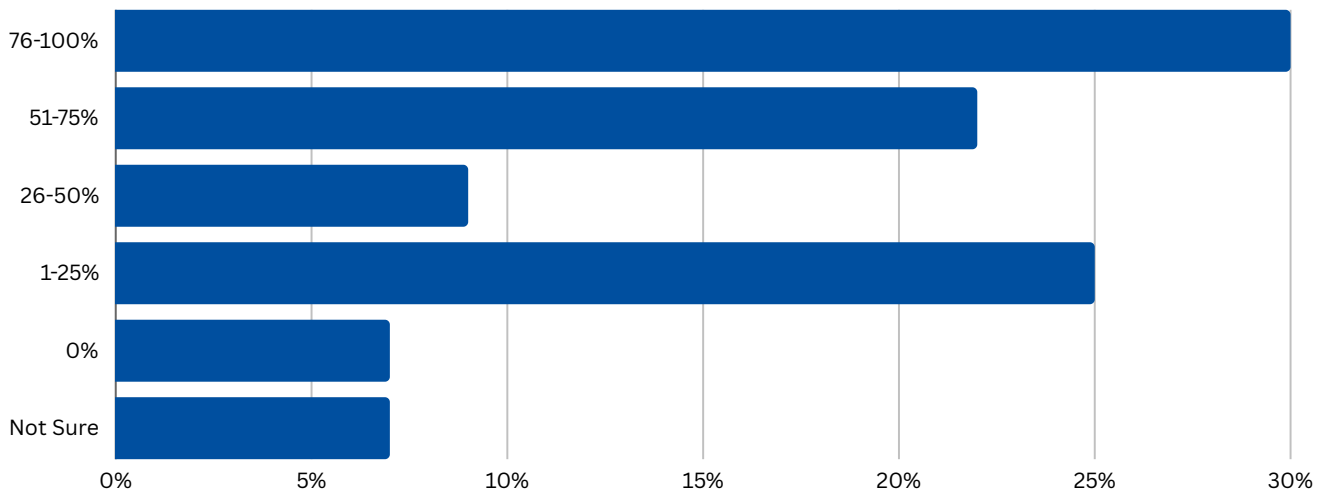
Figure 40: Percentage of integration and collaboration of completed projects: Percentage of integration and collaboration of completed projects

Data Exchange and openBIM

Using data exchange standards such as openBIM can indicate the level of BIM maturity within the organization. OpenBIM is a universal approach to the collaborative design, realization, and operation of buildings based on open standards and workflows. It is an initiative of buildingSMART and several leading software vendors using the open buildingSMART Data Model. The OpenBIM approach offers benefits such as:

- **Interoperability:** OpenBIM supports a transparent, open workflow, allowing project members to participate regardless of the software tools they use.

- **Collaboration:** It creates a common language for widely referenced processes, allowing industry and government to procure projects with transparent commercial engagement, comparable service evaluation and assured data quality.

- **Longevity:** It provides a way to use and maintain building data over time consistently.

This approach allows all stakeholders to participate in modelling, documenting, and analyzing building information. It also ensures that all information is accessible and usable over the life of the building, from inception to demolition.

An organization that has adopted openBIM standards would have worked on using, sharing, and integrating BIM data and models among project participants and are likely to work at a high BIM maturity.

Level of Familiarity:
According to the data, most respondents (38%) were somewhat familiar with openBIM at a surface level. Only 6% of the respondents shared a strong familiarity compared to 11% with no understanding. This showcases varied awareness of openBIM standards and opportunities for improvement. Respondents who were unaware of openBIM were interested in learning more.
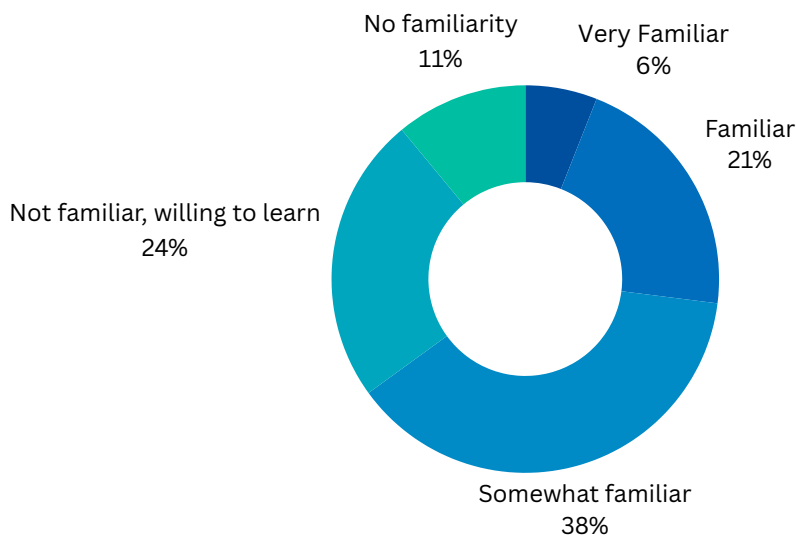

Figure 41: Le: Level of Knowledge about openBIM standards

Limited Adoption:
While 27% of organizations reported using openBIM standards occasionally on a few projects, 22% reported that they currently do not plan to use openBIM standards in their projects.

Respondents suggested that the primary barriers hindering openBIM implementation include a lack of awareness and understanding of openBIM standards. Also, it was highlighted that only a few software vendors largely dominate Canada, whose primary focus is on the short-term use of data on their platform without considering data interoperability with other vendors.
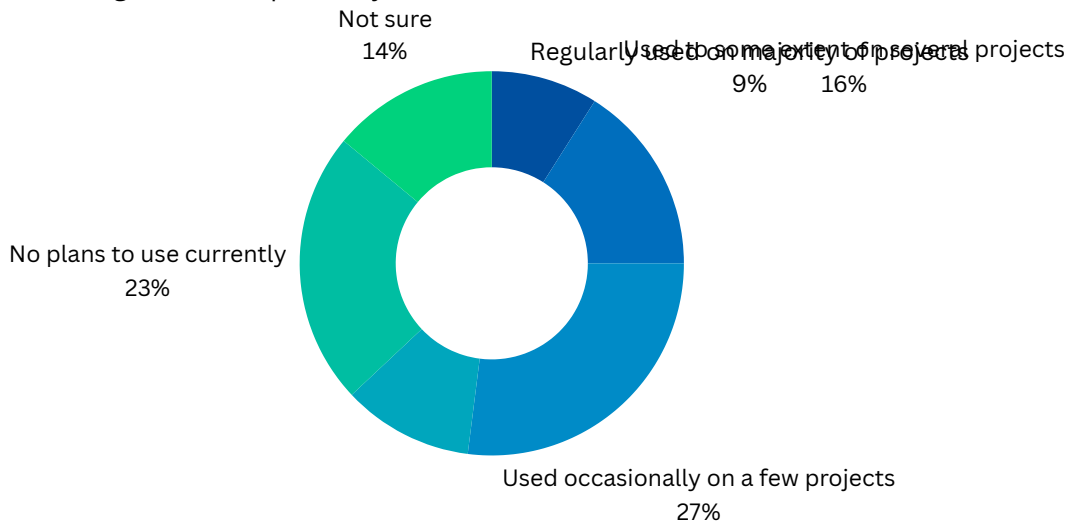
Figure 42: Frequency of using openBIM standards

Implementation Barriers:
Respondents suggested that four significant barriers were limiting the adoption of openBIM standards. The most significant barrier was the lack of awareness and understanding of openBIM standards among industry stakeholders, followed by insufficient training and education on openBIM practice. Resistance to change from traditional workflows, which reflects cultural and behavioural inertia, was also highlighted as a concern. The other barriers to adoption outlined included the benefit of using openBIM being unclear for owners and its issues when working with MEP processes.
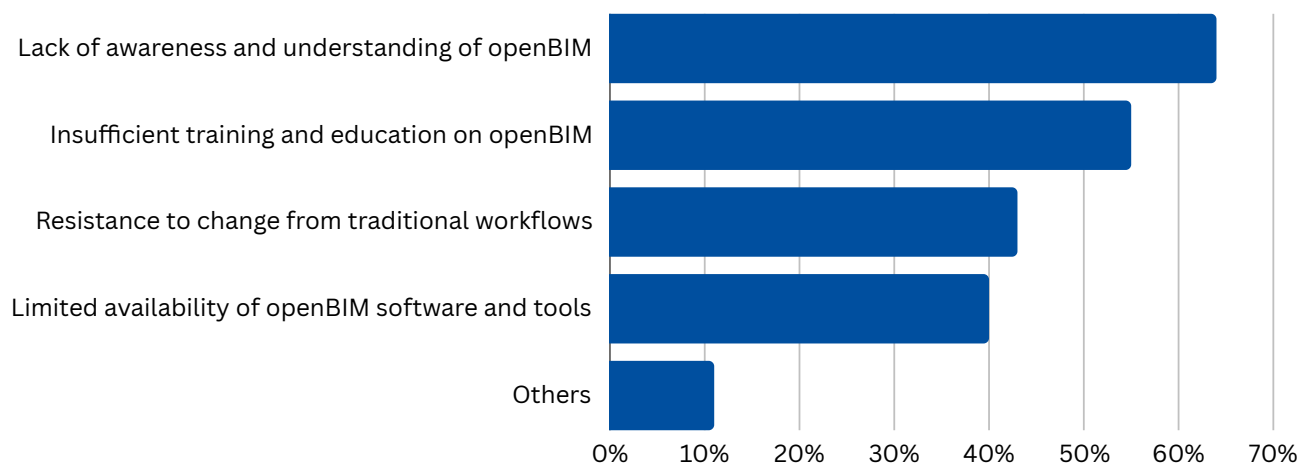
Figure 43: Implementation barriers for openBIM standards

Path Forward:

Respondents expressed the need for clarification around the application of openBIM standards and the need for case studies and examples of their use and implementation. Also, the need for educational resources and training was underscored. It was highlighted that once organizations are equipped with the background knowledge regarding openBIM standards, it will help to overcome the resistance to change from traditional workflows.

Used Occasionally
27%

Used on Several Projects
16%

Not Sure
14%

No Plans to Use Currently
23%

Plans to Use in the Future
11%

Regularly Used
11%
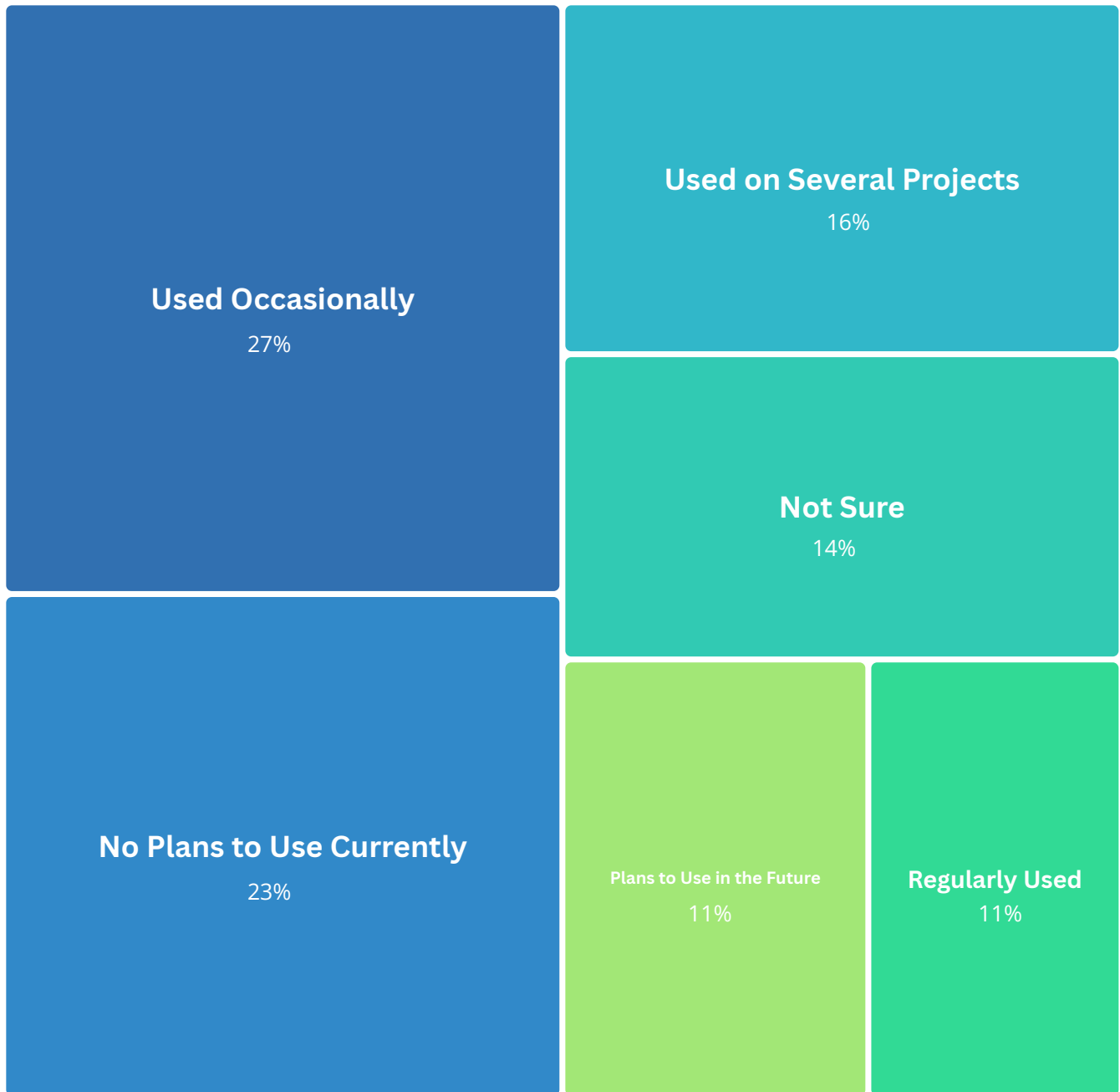
Figure 44: Frequency of openBIM Standards usage on Projects

International Standards

The use of international standards on projects can indicate the level of BIM maturity within the organization. ISO 19650 is an international standard for managing information over the whole lifecycle of a built asset using BIM. It provides a clear path about what is needed, when, and who needs to deliver it. A detailed analysis of industry readiness regarding ISO 19650 is outlined in Part 2 of this report.

If an organization has implemented ISO 19650, it suggests that they have structured processes for implementing BIM and are likely to work at a high BIM maturity.

Limited Usage:
There is currently low adoption of ISO 19650 standards in the industry. The data suggests that 38% of organizations have incorporated them in only 1-10% of their projects, and 34% have not implemented ISO 19650 at all. The lack of adoption signifies the need for greater awareness and education about ISO 19650 and its benefits, as detailed in Part 2 of this report.

Key Takeaways

The Canadian AECOOM industry is experiencing a digital shift, with 30% of organizations incorporating digital deliverables in more than 75% of their projects, indicating a move towards digital technologies. BIM is increasingly contractually mandated, with BIM Execution Plans (BEPs) utilized by 43% of organizations. Expertise in BIM is increasing within the Architectural and Engineering sectors. There is a high level of BIM expertise within Construction Management, General Contracting and Sub-Contracting organizations. 33% of organizations not having any familiarity with openBIM, and 38% of organizations only somewhat knowing about openBIM, openBIM adoption is hindered by lack of awareness & understanding, training & education, and resistance to change from traditional workflows.

ISO 19650 Standards Implementation

About ISO 19650

ISO 19560 is an international standard defining the collaborative processes for effective information management throughout asset delivery and operational phases when BIM is used. It comprises of the following parts:

- Part 1 outlines the concepts and principles of information management using BIM
- Part 2 focuses on the delivery phase of assets
- Part 3 covers the operational phase of assets
- Part 4 addresses information exchange and is currently under development
- Part 5 specifies security-minded BIM, digital built environments and smart asset management
- Part 6 focuses on health and safety and is currently under development

The main intent behind the standard is to provide a clear pathway for information management over an asset's lifecycle, supported through BIM that is based on consistent and specific terminology, concepts, and methods. It also provides a framework for project teams to produce and deliver information using BIM across all asset lifecycle phases.

Current State

Diverse standards:
Organizations in the AECOOM industry use a diverse range of standards. Notably, 70% of organizations have embraced self-developed standards and guidelines, highlighting the industry's inclination toward self-defined norms.
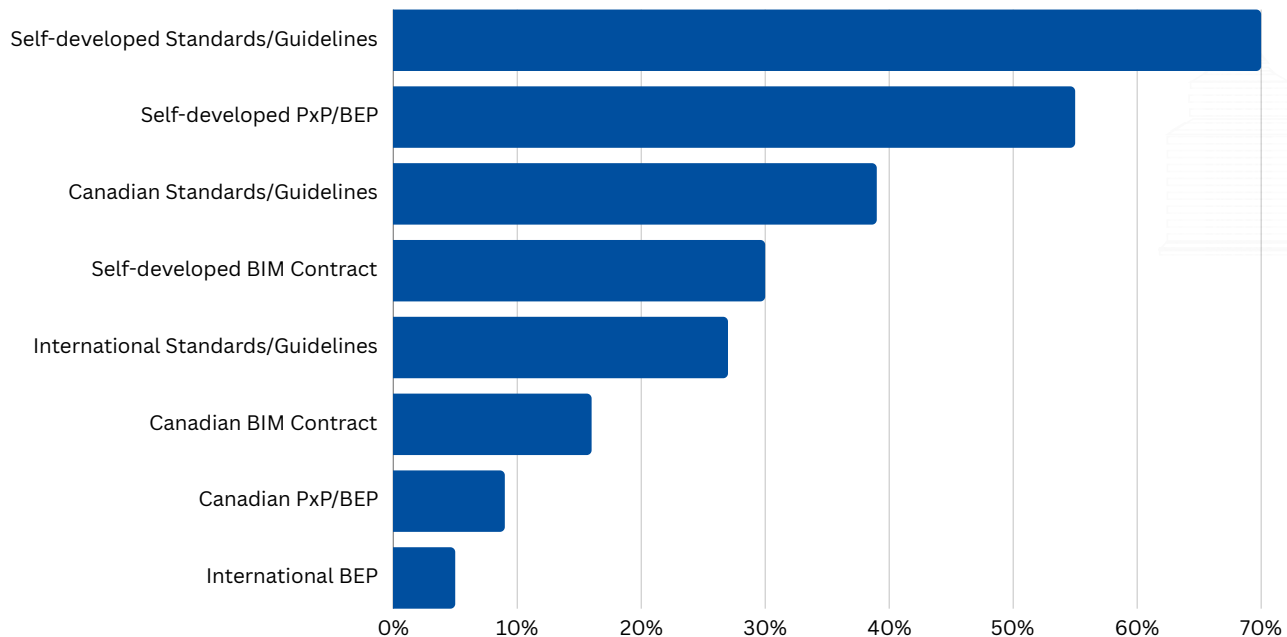
Figure 45: Most commonly used standards

Low ISO Adoption:

There is currently low adoption of ISO 19650 standards in the industry. The data suggests that 38% of organizations have incorporated them in only 1-10% of their projects, and 34% of organizations have not implemented ISO 19650 at all. The lack of adoption signifies the need for greater awareness and education about ISO 19650 and its benefits.
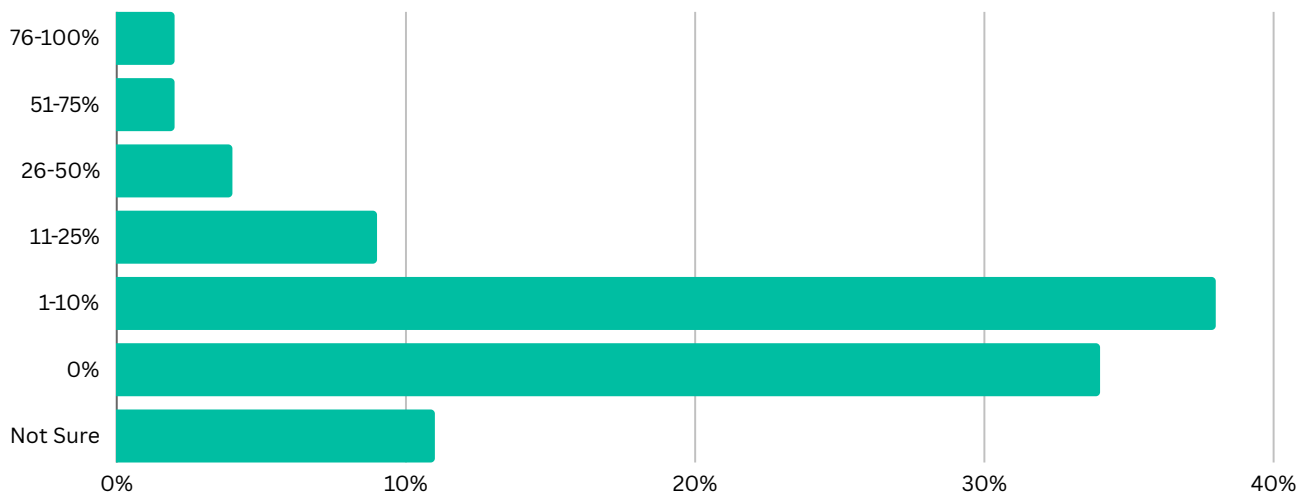
Figure 46: Percentage of projects using ISO 19650 standards

ISO Components and Usage

ISO 19650 implementation involves several components that serve as foundational building blocks for efficient project management and data exchange to align the overarching goals of the ISO framework.

The key components of ISO 19650 are:

Asset Information Model (AIM): A model that includes data and information about a built asset, which is used during the operational phase of a building.

Project Information Model (PIM): The PIM relates to the Delivery Phase of the model and contributes to development of the AIM at the end of the Delivery Phase for use at the start of the asset's lifecycle.

**Asset Information Requirements (AIR):** The information requirements related to the operation of an asset.

Project Information Requirements (PIR): The appointing party's documentation of the information that is required to inform key decisions at specified timeframes during the project's life cycle.

Exchange Information Requirements (EIR): Specific information requirements to be met throughout the delivery phase of an asset.

Organizational Information Requirements (OIR): A document that influences the subsequent information requirements (AIR, PIR, EIR) and project information deliverables (AIM, PIM) of the delivery phase of an asset.

Common Data Environment (CDE): A digital hub where information comes together as part of a typical BIM workflow, serving as a single source of information used to collect, manage, and disseminate documentation, the graphical model, and non-graphical data for the whole project team.

Federation Strategy: An information container structure taking into account purpose, Level of information need, and security of the information (permitted use).

Responsibility Matrix: The Responsibility Matrix sets out the responsibility for the production of information and models for each defined project stage and to what Level of Definition.

BIM Contract Appendix: The appendix is designed for standard construction contracts covering topics like copyright and model element ownership.
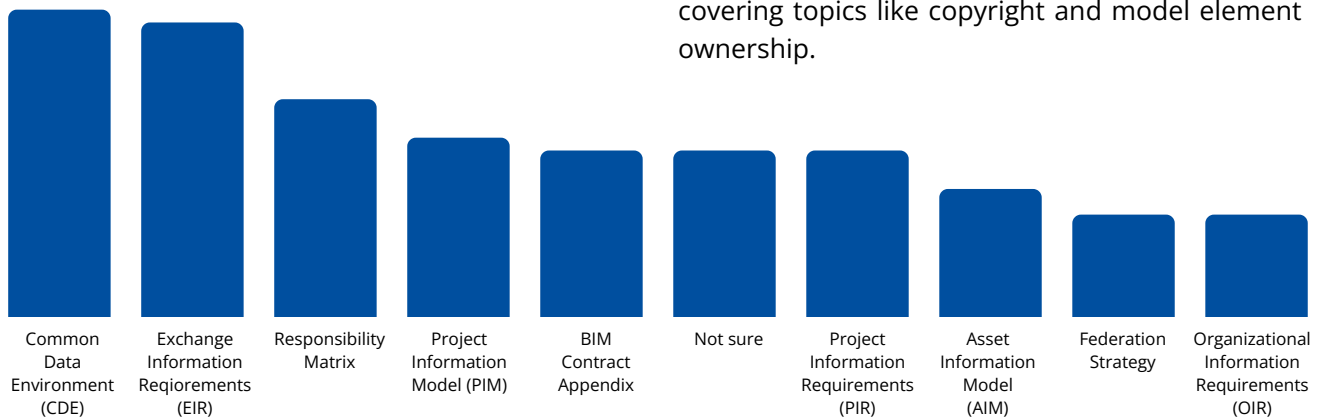

Figure 47: ISO 19650 components delivered or utilized on completed projects

The ISO 19650 framework requires developing a clear and detailed information delivery strategy as a part of the EIR.

Only 19% of the organizations have a fully finalized approach to delivering client requirements that address all information requirements, level of information needed, acceptance criteria, milestones, and collaborative production goals. At the same time, 40% of the organizations have started working on defining their information delivery strategy.
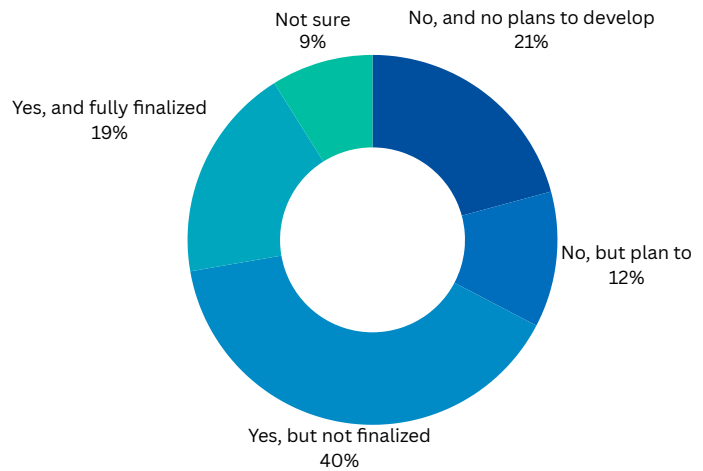
Figure 49: Status of information delivery strategy development
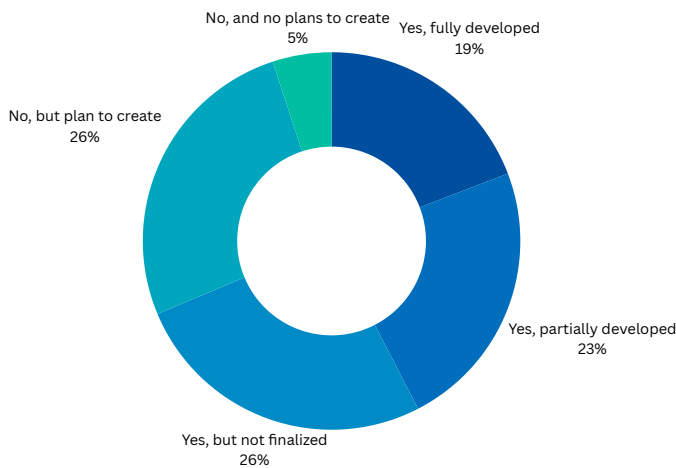
Figure 48: Status of responsibility matrix development

Similarly, a detailed responsibility matrix is a critical component of ISO 19650 that lists all elements, responsible parties, and deliverables for each element.

While 19% of the organizations have a detailed responsibility matrix developed, 23% have a pre-contract responsibility matrix that communicates the first iteration of the task team deliveries.

Part 5 of the ISO 19650 is a specification for security-minded information management. It provides a framework to assist organizations in understanding the critical vulnerability issues and the controls required to manage the security risks. The standard describes a process to plan for and mitigate the risks associated with the digitization of information.

Notably, 30% of the organizations have robust security plans developed, while 23% have a well-defined strategy for creating the information security plan.
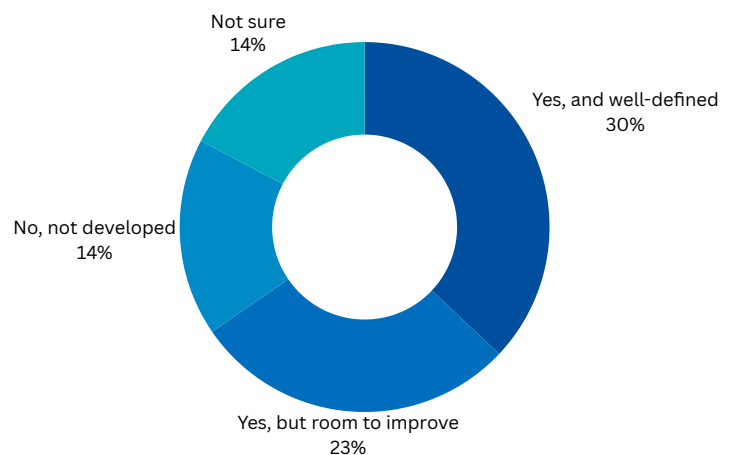
Figure 50: Status of information security plan development

The ISO 19650 standard includes clear procedures for quality assurance and quality control (QA/QC) in managing information throughout the delivery and operational phase of assets when BIM is being used. These procedures are outlined in the Statement of Work and CAD/BIM Standard.

Encouragingly, 30% of the organizations have a well-defined QA/QC process, whereas 33% have established some QA/QC procedures, but they may still need to be fully detailed or documented.
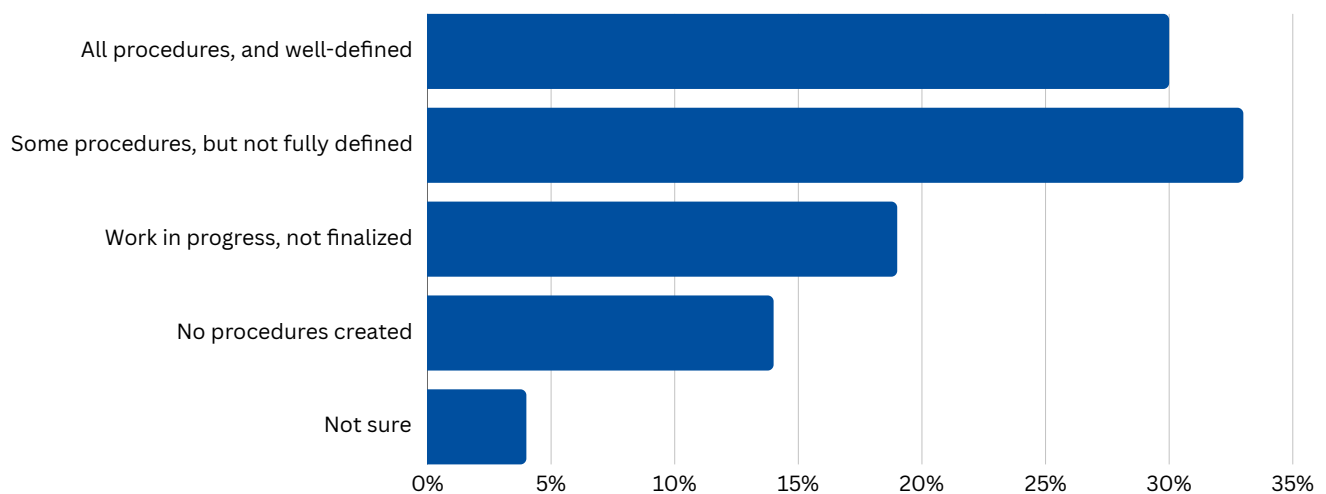
Figure 51: Status of QA/QC process development

Implementation Hurdles

While the ISO 19650 standard aims to facilitate better collaboration, ensure accurate information sharing, and improve the quality of information access, respondents have met some hurdles during implementation in practice.

Responding to requests for proposals:
ISO 19650 requires proponents to submit pre-contract documents consisting of a pre-BIM Execution Plan, a high-level responsibility matrix, a risk register, and a mobilization plan in the proposal response.

- The Pre-BIM Execution Plan (pre-BEP) outlines how the delivery team will manage information and demonstrates their approach, capability, and capacity to meet the Exchange Information Requirements (EIR).

- The High-Level Responsibility Matrix is a chart that delineates the participation of various functions in completing tasks or deliverables, identifying the responsibility for each element of the Information Model.

- The Risk Register helps identify and understand risks associated with information production and delivery, assuring the appointing party.

- Lastly, the Mobilization Plan details the mobilization of the Delivery Team's resources following the Information Standard in the appointment.

Respondents highlighted multiple hurdles while developing the pre-contract documents, wherein the majority reported the lack of clarity or understanding of the client's requirement at the proposal stage of the project as the major hurdle. Furthermore, unfamiliarity with developing pre-contract documents and limited resources highlighted the need for support documentation for drive the adoption of the standard.

Figure 52: Challenges in developing and including the pre-contract documents during proposals

Naming Conventions:

Naming conventions are pivotal in standardizing project terminology and organizational practices to improve clarity and consistency. These conventions can present challenges due to the variations in project-specific implementations. ISO's file naming conventions have been seen to be onerous and frequently criticized for length and complexity, leading to only 7% of the organizations standardizing naming and numbering conventions for BIMs per ISO 19650.
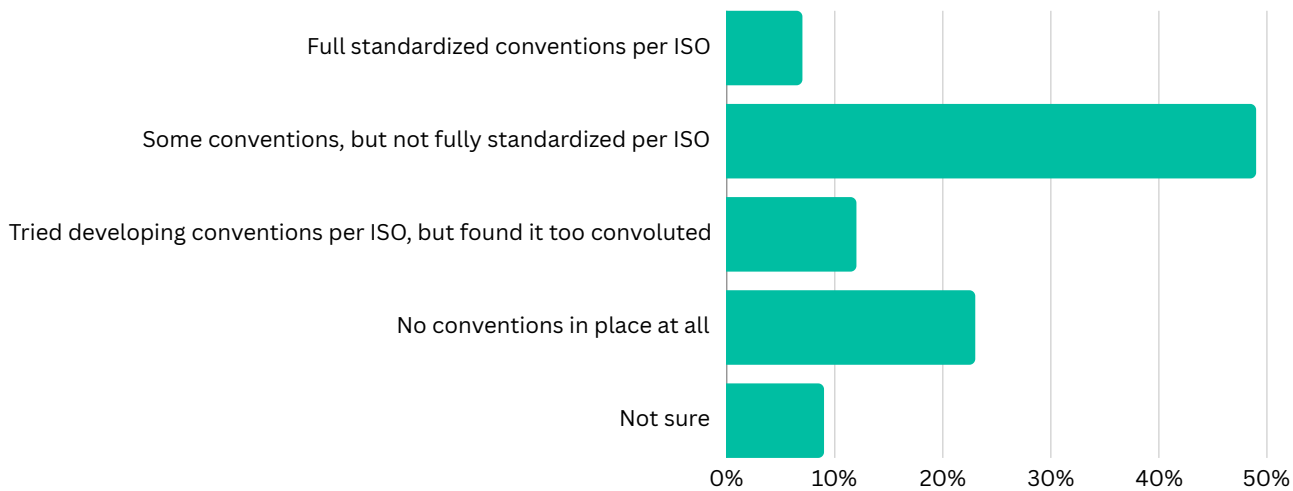
Figure 53: Status of naming conventions development

Challenges and Practical Insights

Language Complexity and Effort Shift:
ISO 19650 provides a common language and framework for the industry. However, its adoption is hindered by terms and language that do not easily translate to the Canadian context. The standard's prescriptive nature and the front-loaded efforts required for ISO 19650 pose additional challenges.

Project-Level Standardization and Cost Considerations:
Standardizing parameters and unique IDs at the project level is crucial for coherence and interoperability. While ISO 19650 may introduce initial cost increase due to adopting new workflows, these are often outweighed by efficiency gains achieved through robust BIM implementation.

Comprehension and Support Needs:
ISO 19650 strives to establish a standardized language within the industry. However, comprehension levels among stakeholders vary considerably. This emphasizes the need for enhanced support and resources to facilitate understanding of the complex language used in ISO 19650.

Owners' Awareness and Learning Journey:
ISO 19650's journey begins with owners' information requirements. Yet, there is a notable gap in owners' awareness of ISO 19650 within the industry, highlighting the need for targeted education initiatives.

Information Management and Security:
In ISO 19650, an information management policy refers to the set of rules for organizing, controlling, and delivering information throughout a built asset's lifecycle. It includes guidance on managing the common data environment (CDE), which involves managing information container states through metadata assignment. The goal is to standardize information management practices in building information modelling (BIM), ensuring coherence and interoperability across different stages of a built asset's lifecycle.

However, 70% of organizations have not yet developed information management policies and plans in alignment with ISO 19650. This highlights the need for comprehensive implementation strategies and clarity in managing information security

70%

YET TO DEVELOP

INFORMATION MANAGEMENT POLICY

Path Forward

Training and Education:
The journey toward ISO 19650 implementation emphasizes the need for knowledge and resources. Currently, ISO 19650 usage within organizations is low, but an encouraging 47% of organizations plan to provide training on ISO 19650 standards in the future. This reflects the evolving industry landscape, where education is a fundamental driver of widespread adoption.

Outlining Potential Impact:
ISO 19650 can assist in outlining how models and data should be used for downstream consumption. It may lead to an initial cost bump due to new workflows, but the efficiency gains of good BIM implementation could be recognized over time.

Need for champions:
To promote ISO adoption within construction projects. Owner education on ISO is also crucial for optimizing data usage and achieving comprehensive asset information.

Key Takeaways

The ISO 19650 standards implementation represents a journey filled with potential and challenges. Stakeholders gradually recognize its importance, yet comprehensive education and training efforts are imperative to unlock its full potential. Industry-wide standardization, owner engagement, and addressing language complexities are pivotal in shaping the future of ISO 19650 implementation within the construction sector. Overcoming initial barriers is key to harnessing the long-term benefits and efficiencies offered by ISO 19650 standards.

BIM Adoption: Enablers and Barriers

Unlocking Success: BIM Enablers

In exploring BIM adoption and implementation within the Canadian construction sector, respondents shared crucial insights into the enablers that can help to drive the successful integration of BIM.

Business Advantages

Enhanced Efficiency:
BIM empowers stakeholders to streamline project delivery by fostering close collaboration with consultants, ensuring rigorous standards, and facilitating asset tracking, ultimately leading to efficient project management and reduced costs.

Risk Mitigation:
Leveraging BIM for risk identification and seamless coordination minimizes project disruptions, enhances decision-making through visualization, and significantly reduces unforeseen challenges, thereby safeguarding business investments and reputation.

Knowledge Empowerment

Staff Training: Mandatory BIM training tailored to project specifics and the demonstration of tangible benefits to clients plays a pivotal role in promoting adoption. Empowering project teams with the necessary skills and knowledge ensures they are well-equipped to harness the full potential of BIM.

Standardization: Standardization emerges as a critical enabler. Establishing uniform standards aids in developing effective training materials, reduces the learning curve, and aligns educational partners with the evolving needs of the industry. This standardization streamlines the adoption process, making it more accessible and efficient.

Owner-Driven Momentum

Owner Demand and Stakeholder Experience: The driving force behind BIM adoption often originates from owner demand, particularly when stakeholders have previously experienced the benefits of BIM projects. This owner-driven momentum fuels enthusiasm for BIM implementation and sets the stage for its successful deployment.

Owner Awareness:
Enhancing Owner awareness regarding BIM's advantages is a vital enabler. Educating owners about the transformative potential of BIM technology fosters an environment conducive to its adoption.

Enhanced Roles and Awareness

VDC Roles and Owner Awareness: Incorporating Virtual Design and Construction (VDC) roles into staffing plans and raising owner awareness serve as key enablers. Assigning dedicated roles for VDC within projects ensures that BIM is fully leveraged for improved outcomes. Additionally, increasing owner awareness of BIM's potential enhances its project integration.

Educational Programs: Integrating BIM into college and university programs and curricula is essential for fostering an ecosystem of knowledgeable professionals. Some individuals may lack comprehensive process understanding despite possessing software knowledge. Educational programs bridge this knowledge gap, enabling future professionals to grasp the significance of BIM.

Overcoming Obstacles: BIM Barriers

In tandem with enablers, respondents highlighted persistent barriers that continue to challenge the seamless implementation of BIM in construction projects.

Understanding the Value

Learning Curve vs. Tool Knowledge:
Distinguishing between learning BIM tools and developing a comprehensive understanding of BIM as a process is essential. Challenges arise when stakeholders fail to recognize the full value of BIM and focus on the technology or specific software, making it crucial to bridge this gap through targeted education and awareness initiatives.

Sub-Consultants and Stakeholder Skills:
Varying skill levels among sub-consultants and other stakeholders create coordination challenges. Finding the right partners with the requisite BIM expertise remains a hurdle in achieving cohesive BIM implementation.

Process Improvement Focus:
Process improvement may not always be a priority for stakeholders, primarily due to an incomplete understanding of BIM's comprehensive value. Fostering a mindset that prioritizes process enhancement is essential to overcome this barrier.

Owner and Consultant Understanding:
The lack of realization and deep understanding by owners and/or consultant of BIM's value is a key barrier to overcome. By elucidating the transformative benefits of BIM, collaborators can make informed decisions and fully embrace its implementation.
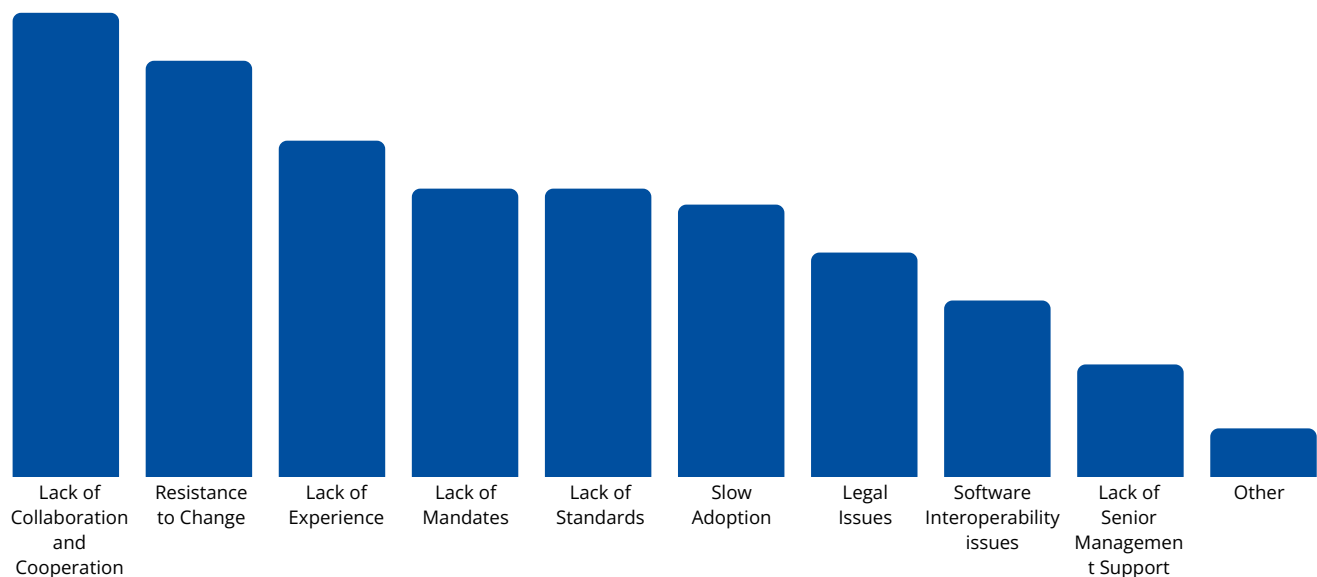

Figure 54: Persistent challenges on BIM projects

Knowledge Gaps and Accessibility

Inconsistent Standards Between Organizations:
Differences in standards and processes across organizations pose a significant barrier to standardization efforts. Streamlining processes and fostering alignment among organizations is essential to mitigate this challenge.
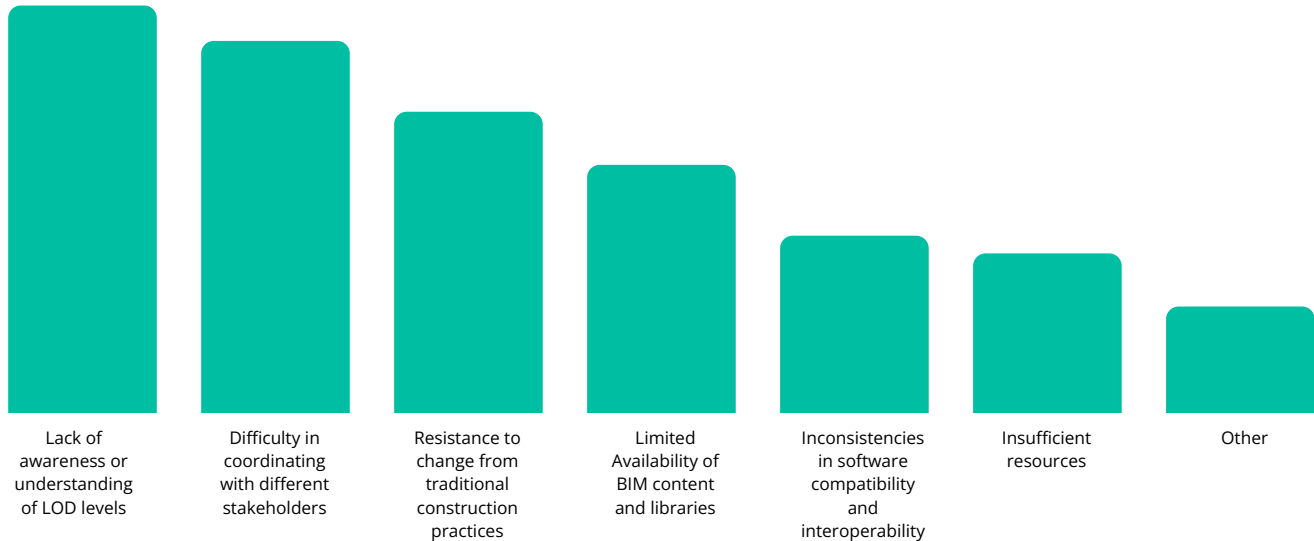
Figure 55: Implementation challenges with Level of Information (LOI) and Level of Detail (LOD)

Industry Readiness and Upskilling

Legacy workflows:
Respondents highlighted reliance on legacy workflows and short-term planning as common challenges for adopting BIM. The need to consider BIM for the whole asset lifecycle and the lack of support for ongoing projects were highlighted as well.

Consultants Leading the Way:
Consultants play a pivotal role in driving the sharing of BIM models, given their deep understanding of the value they bring to construction. Their leadership is instrumental in propelling the industry towards BIM adoption.

Limited Owner Involvement:
Owner advocacy for BIM remains limited, with minimal focus on the BIM process and digital delivery. Raising owner awareness about the transformative potential of BIM and its broader benefits is essential for comprehensive adoption.

Upskilling:
In-house upskilling is the preferred approach over third-party options. However, the initial setup may lead to skill loss. Addressing this challenge involves continuous training and skill development to ensure that BIM expertise remains current.

Integrated Project Delivery

Practical Insights:

Integrated Project Delivery (IPD) is a project delivery method by which key parties involved in the design, fabrication, and construction aspects of a project are joined together under a single agreement. This allows for ongoing communication and collaboration throughout the project's phases which decreases waste while increasing efficiency, respect for team members, and project outcomes including profits.

BIM is often connected to IPD because they are both highly collaborative, the tool and process work hand-in-hand with the project delivery method, allowing for fuller realization of BIM's capabilities.

IPD offers both positive aspects and challenges. While it ensures equitable compensation, facilitates the creation of dedicated BIM departments, and encourages collaboration, initial resistance from some trades and additional resource requirements can pose obstacles.

Over time, the value of IPD and collaboration becomes increasingly apparent. Patiently navigating the initial challenges ultimately leads to the appreciation of its benefits.

Key Takeaways

The BIM journey within the Canadian AECOOM sectors is marked by both enablers and barriers. It is crucial to align BIM implementation with the project's scope, particularly during the procurement phase, to ensure alignment with project goals. This involves establishing a clear pathway that aligns BIM with the entire development lifecycle, which helps prevents information loss, wasted efforts, and results in optimization of information management. A culture of accountability and efficient resource management is essential for effective BIM execution. It's also important to recognize that the utility of BIM extends beyond owner requirements, leveraging its use across all phases.

Government Mandates

Status Quo

Contractual Digital Deliverables:
Most 61% of organizations reported that digital deliverables or models were contractually mandated in less than 25% (or a quarter) of their projects, underscoring the need for the industry's broader shift toward digital documentation.
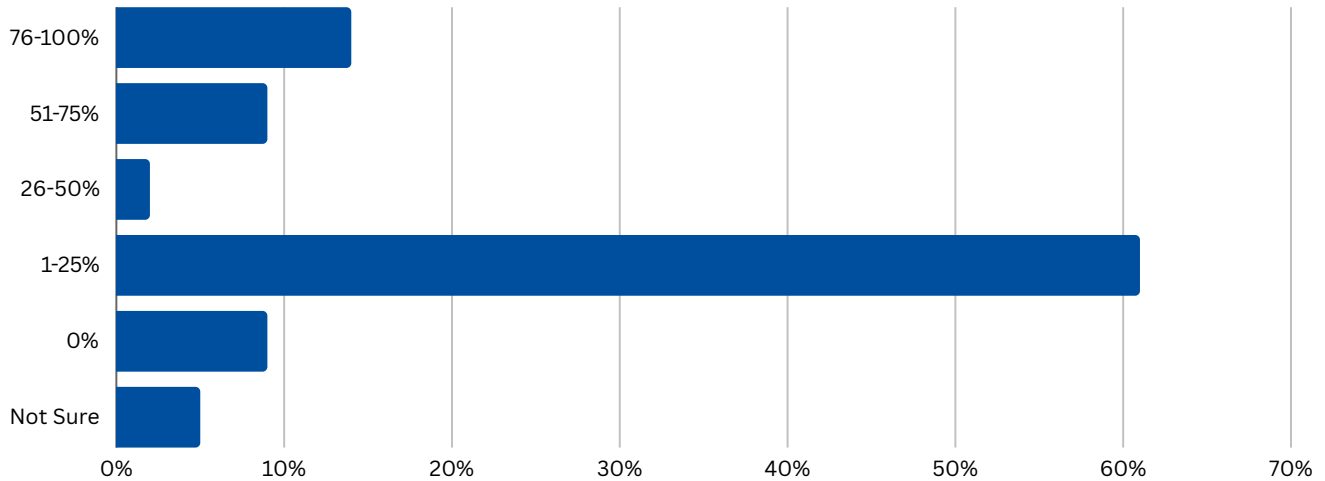
Figure 56: Percentage of projects contractually requiring digital deliverables

Contractual BIM Requirements:
The contractual requirements for BIM processes are inconsistent across projects and organizations. 52% of organizations reported that they were required to implement BIM processes for 1-25% (less than a quarter) of their projects. Only 9% of organizations were required to implement BIM processes for 76-100% of their projects, suggesting a growing recognition of the value of BIM for design and construction but also a need for improvement and standardization.
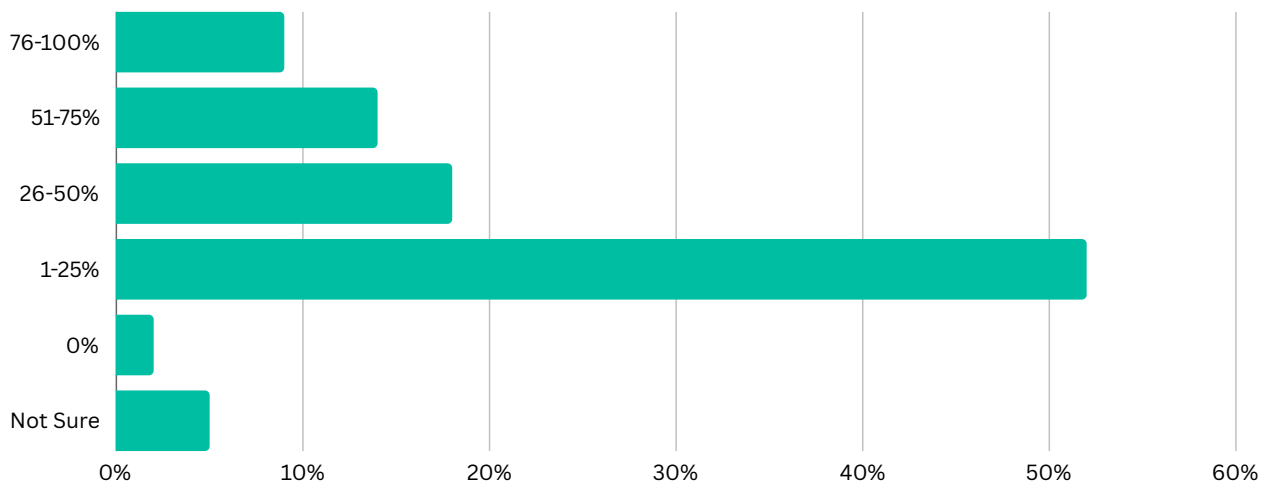
Figure 57: Percentage of projects with contractual requirements for BIM processes

BIM Contract Appendix:

The BIM contract appendix is a document that defines the roles, responsibilities, and deliverables of the parties involved in a BIM project following the ISO 19650 standard for information management. It covers topics such as copyright, model element ownership, information exchange, BIM use, level of development, and model organization. Most organizations have not utilized the BIM contract appendix. Among those who have, challenges encountered include onboarding all stakeholders to use the appendix, integration into existing workflows, and obtaining required data.
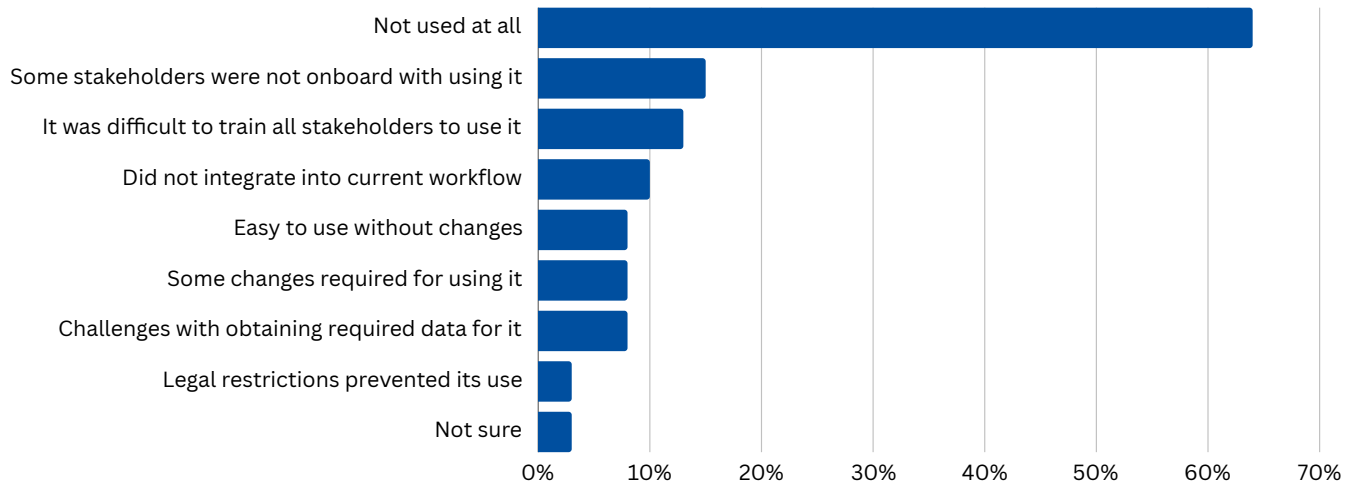
Figure 58: Experience with BIM contract appendix from ISO 19650: Experience with BIM contract appendix from ISO 19650

International Mandates Awareness:

Countries across the globe have established BIM mandates, such as in the UK; BIM has been mandatory for every public project since 2016. In France, the Digital Transition Plan for Construction aimed to implement BIM methodology throughout the country by 2022 fully. In Singapore, BIM submission is compulsory for all new building projects with more than 5,000 square meters of gross floor area since 2015. In Brazil, BIM is mandatory for public works of architecture and engineering from 2021 onwards.

Awareness of International BIM mandates is increasing in the Canadian industry, with 52% of organizations being somewhat aware, and 27% are well aware that other countries worldwide require BIM and digital delivery for asset management to owners or as part of the regulatory submission.
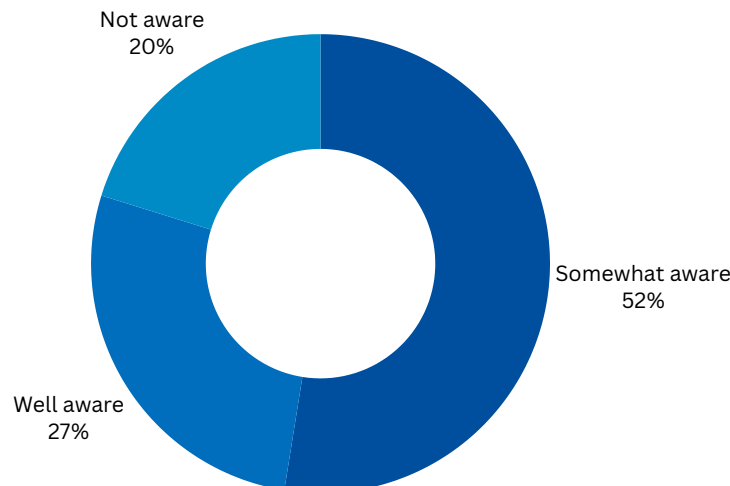
Figure 59: Level of awareness about international BIM mandates

Industry Openness

Government as a Catalyst:
Respondents unanimously acknowledged that government intervention is essential to accelerate BIM adoption and standardization. While the industry recognizes the benefits of BIM, it was collectively agreed that a push from regulatory bodies was required to ensure a more widespread and consistent implementation.

Provincial vs. Federal Mandates:
The choice of jurisdiction for mandates carries implications for the scope and effectiveness of the mandates. The respondents highlighted that the government's plan to complement mandates should be communicated in advance with the industry.

openBIM mandates

Planning Approvals and Building Permits:
The majority of the organizations are in favour of a regulatory government openBIM mandate for planning approvals and building permits. 75% of the respondents either strongly support or support the idea of such a mandate, while only 9% oppose it, and none strongly oppose it. This suggests that there is a high level of acceptance and enthusiasm for openBIM among the organizations in the construction industry.

Submission to Owners:
The majority of the organizations are in favour of a government openBIM mandate for submission to owners. 61% of the respondents either strongly support or support the idea of such a mandate, while only 11% oppose it, and none strongly oppose it. This implies a high level of confidence with openBIM among organizations in the construction industry.
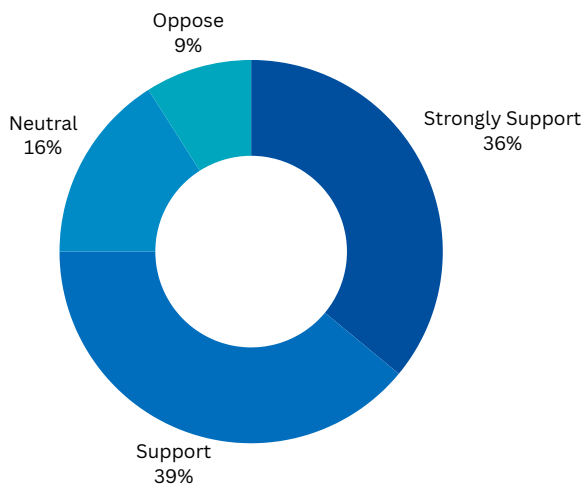
Figure 60: Level of support for openBIM mandate for planning approvals and building permits
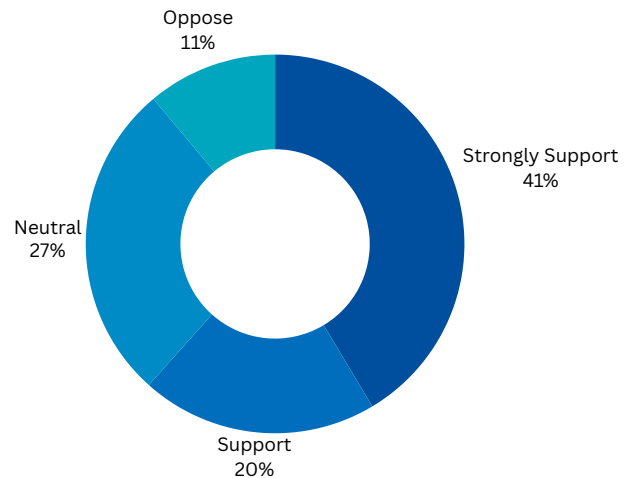
Figure 61: Level of support for openBIM mandate for submission to owners

Model as Legal Deliverable

BIM Models as Contracts:
Respondents explored using the BIM model as a legal deliverable (MALD) in design and construction projects, suggesting that this approach could bridge communication gaps and enhance project clarity.

Foreseeable Challenges:
Challenges were identified with defining "good" models, owner education, and distinguishing between trade and design models. Rather than strict MALD mandates, collaboration was seen as a more practical approach.

According to most respondents, the main foreseeable challenge would be the lack of knowledge and education on the proposed mandate, drawing from the experience using BIM and collaborative delivery models. Furthermore, the second biggest challenge would be the lack of industry readiness and the need to overcome technical, organizational, and cultural barriers. Respondents emphasized the need for clarity and consistency during the implementation of the mandates to encourage the industry's uptake.
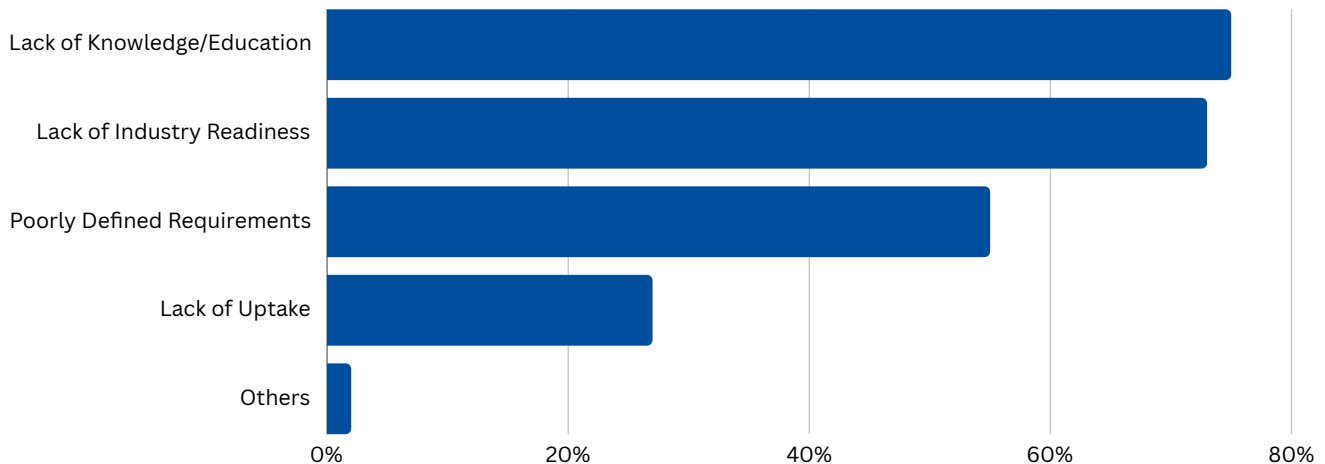
Figure 62: Foreseeable challenges with government mandates

Challenges and Considerations

Disruption and Industry Silos: Mandates may disrupt established practices, potentially creating industry silos. However, they can also drive standardization, improve database consistency, and facilitate certification processes.

Impact on Small Businesses: The potential impact on small businesses within the AEC industry was highlighted as a challenge. Balancing the benefits of BIM with potential market disruptions is crucial.

Technical Enforcement: Government mandates can technically enforce BIM usage on their projects. However, extending this enforcement beyond government projects requires careful consideration, as per the respondents.

Costs and Value: Government must understand the costs and value associated with BIM implementation to make informed decisions regarding mandates

Strategic Implementation

Phased Approach: Engagement insights recommended a phased implementation strategy, considering project size and complexity. This approach allows stakeholders to adapt gradually, reducing the potential for disruptions.

Market Readiness: The readiness of the AEC market for BIM implementation varies by region and industry capacity. Successful mandates must account for these variations.

Owner and Project Manager Influence: Contractual requirements from project owners and managers can be powerful drivers of industry change.

Clarity Over Complexity: Respondents advocated for clear and straightforward requirements and mandates. Complexity can hinder adoption and compliance.

Education and Grants: Participants emphasized the importance of educational programs and grants to support in-house training. Equipping professionals with the necessary BIM skills is critical to successful implementation. Furthermore, participants stressed the importance of continuous education and academic integration of BIM.

Collaboration and Certification: Collaboration between industry and government, while addressing concerns of dominance by large companies, was identified as a valuable best practice.

International Standards Alignment: Aligning mandates with established international standards, such as the UK's BIM standards, was seen as a beneficial approach to ensure interoperability and consistency.

Government As a Catalyst

The participants acknowledged that government intervention is essential to accelerate BIM adoption and openBIM data standardization. They felt that while industry adoption of BIM is a validation and recognition of BIM's importance in industry, a push from government regulatory bodies is required, as has happen in other major industrialized countries.

Much of the respondents request for government intervention is influenced by both a knowledge of BIM adoption through government mandates in European countries and elsewhere, as well as a recognition that to appropriately address the scope of BIM implementation standards required for Canadian industry would take more than a passing node from government.

Understanding the National Standards System for Canada

The Government of Canada does not mandate standards directly. They have put in place a three tier system designed to promote voluntary standards development in an industry through government and industry collaboration. An industry adopts the standards and best practices it developed through a collaborative process. The government then mandates that standard on behalf of that industry.

Mandate for Standards Development

In Canada, the Standards Council of Canada (SCC) / Conseil Canadian des Normes (CCN) is the Canadian organization with the mandate to promote voluntary standardization in Canada. SCC reports to parliament through the Minister of Innovation, Science and Economic Development.

SCC sets the criteria for a standard that has been developed to become a National Standard of Canada (NSC) and accredits Standards Development Organizations (SDO) to jointly develop that standard with industry and submit to SCC for NSC approval.

SCC represents Canada in both International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC).

Standards Development Organization

SCC accredits SDOs in Canada. This accreditation verifies that the SDO is competent to carry out standards development and certification functions and is based on internationally recognised criteria and procedures. The SDO presents the standard to SCC who validates it meets the NSC criteria. The standard must: be developed by consensus of a balanced committee of stakeholders, undergo public scrutiny, be published in both official languages, be consistent with or incorporate existing international and pertinent foreign standards. Also, National Standards must not act as a barrier for trade.

buildingSMART Canada, the Canadian Chapter of buildingSMART International recently completed a study commissioned by the Canadian Standards Association (CSA)

Key Takeaways

Government mandates are instrumental in shaping the landscape of BIM adoption and standardization. The insights and considerations shared by survey respondents and workshop participants highlight the significance of government intervention, the need for practical phased approaches, and the importance of education and alignment with international standards. Challenges, such as market disruptions and data security, underscore the complexity of implementing mandates. International experiences offer valuable lessons for effectively driving BIM adoption and reaping its benefits.

Leaders should closely monitor potential industry consolidation resulting from BIM mandates. Strategies to support small and medium-sized businesses during this transition should be considered. Effective leadership involves actively seeking feedback from industry stakeholders and incorporating their insights into the continuous improvement of BIM mandates.

Owners' Leadership

This section delves into the crucial role of owners, both public and private, have in supporting and overseeing Building Information Modeling (BIM) implementation across the built environment. Effective owner leadership is instrumental in driving the successful implementation of BIM mandates, aligning with industry needs, and fostering innovation while addressing both short-term challenges and long-term objectives.

Training and Expertise

Guidance and Direction:
Owner leadership is expected to provide criteria and learning outcomes for training programs to equip industry stakeholders with the knowledge and skills to understand and effectively implement BIM processes and technologies. This includes expert guidance on BIM standards and their practical application. Owner's project goals and asset management goals will guide the delivery team to work toward the same objectives that serve long-term operational needs and support the built environment.

Awareness and Education:
Public sector owners should focus on raising awareness about the importance of BIM adoption and its benefits to the building and infrastructure sectors for the short and long term benefits. Educating stakeholders, including contractors, architects, and engineers is essential for successful BIM integration to support strategic and project goals.

Cost-Benefit:
Owners should conduct thorough cost-benefit analyses to assess BIM mandates' potential short-term cost implications against long-term return on investment. This analysis informs stakeholders about the financial aspects and helps manage expectations.
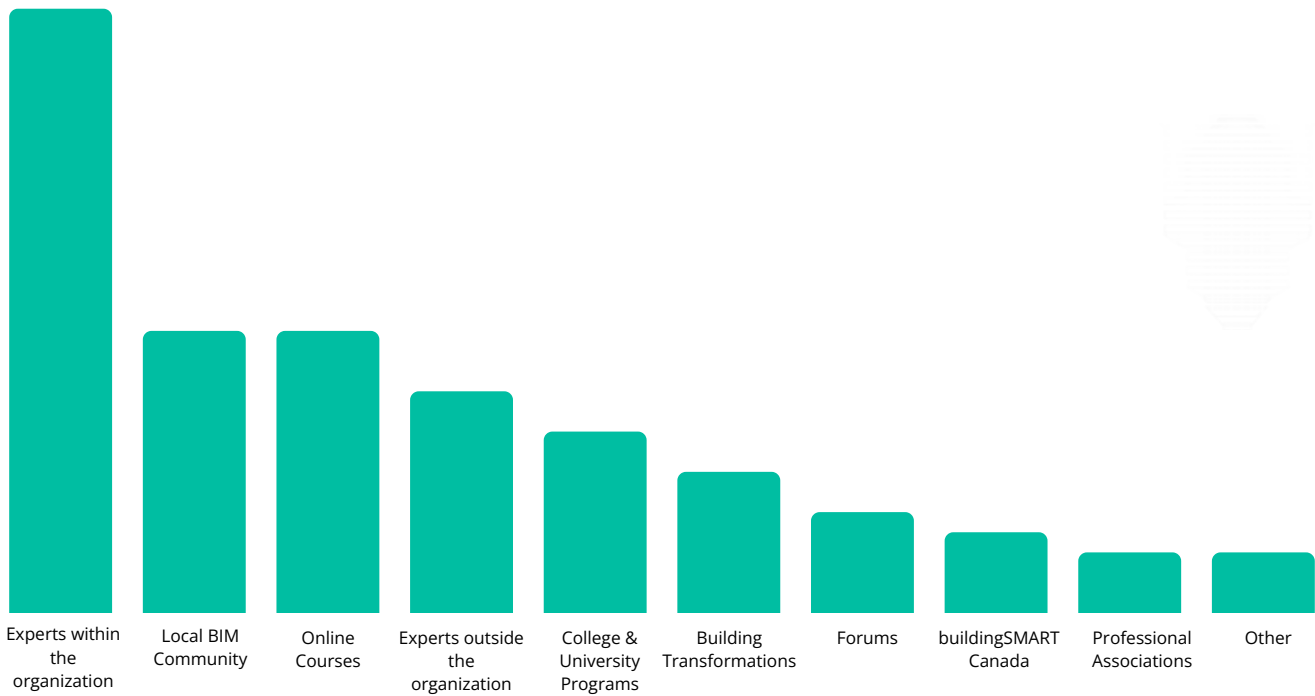

Figure 63: Sources of information used for upskilling

Required Resources:

Most respondents (95%) mentioned industry training and upskilling as the critical resources required for successful BIM implementation, highlighting the workforce's need for more knowledge and skills in using BIM. The need for BIM contracts defining BIM projects' legal and contractual aspects was a close second, highlighted by 85% of the respondents.

Furthermore, the need for support resources, such as best practices, guidelines, and documents, which provide guidance and assistance on how to apply and adopt BIM standards and protocols was mentioned. Additionally, standards and manuals that can provide consistency and clarity on what BIM involves and what BIM deliverables should be were specified.
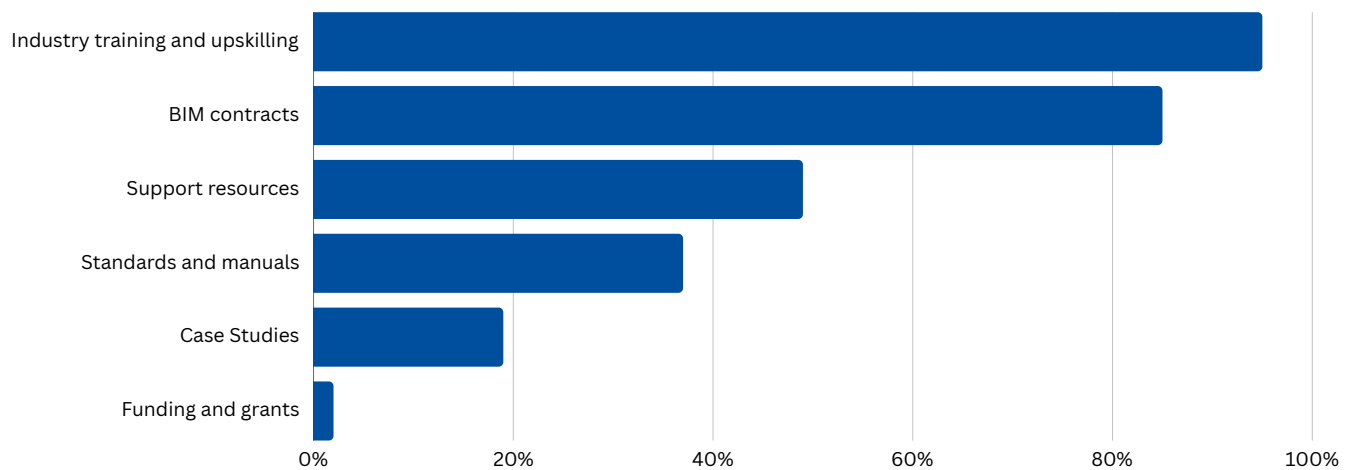
Figure 64: Resources required for successful BIM implementation

Funding and Documentation

Documentation: Clearly articulated BIM requirements at the project proposal phase with standardized documentation is essential for transparency and consistency in BIM implementation.

Platform Agnostic: Emphasizing platform agnosticism is a strategic direction owners can advocate. This encourages interoperability among various BIM software platforms and prevents vendor lock-in effects.

Defining "What" Over "How": Owners should guide the stakeholders by outlining "what" needs to be accomplished rather than prescribing "how" it should be done. This approach provides flexibility for innovation while maintaining compliance with BIM requirements and deliverables.

Interpretation of LOD: Owners should clarify the interpretation of the Level of Development (LOD) concept, emphasizing the importance of resolution in BIM models over excessive detail. This ensures consistency in LOD application.

Owner Support

Owner Education: Participating in owner education and awareness programs is recommended as owners play a pivotal role in BIM adoption and must clearly understand their requirements and responsibilities in BIM projects.

Resource Directories: Government leaders can establish resource directories to guide those with limited BIM experience toward the right experts and resources. This promotes accessibility and inclusivity in BIM adoption.

Financial Support: Government leaders can allocate funding to support contractors in pricing BIM into their projects. Financial incentives, such as tax incentives for hiring BIM professionals, can further motivate BIM adoption.

Collaborative Forums: Industry roundtables, workshops, and collaborative forums organized by government leaders provide a platform for stakeholders to share knowledge, best practices, and experiences. These forums foster a culture of collaboration and learning.

Key Takeaways

Owner's project goals and asset management goals will guide the delivery team to work toward the same objectives that serve long-term operational needs and support the built environment.

Owner leadership expectations in supporting BIM mandates encompass a spectrum of responsibilities, from guidance and oversight to fostering industry collaboration and innovation. As the driving force behind BIM use, owners are entrusted with creating an environment conducive to BIM integration while simultaneously managing short-term challenges and steering the stakeholders toward long-term success of information management to support the creation and maintenance of the built environment.

Diffusion of BIM Across Provinces

The following table provides an overview of the state of BIM mandates across provinces and the marquee BIM communities, helping share knowledge and expertise. Some notable BIM projects completed recently are outlined below.

Province/ Territory	BIM Mandates/ Guidelines	BIM Communities	Notable BIM Projects
British Columbia	- No provincial mandate - BC Housing has BIM requirements	BIMbc	- Vancouver House - Rogers Arena Renovation - BC Children's and Women's Hospital Redevelopment - Evergreen Line Rapid Transit Project - Oakridge Centre Redevelopment
Alberta	- No provincial mandate - Alberta Infrastructure has BIM requirements	Calgary BIM Community (cBIMc)	- Royal Alberta Museum - Stantec Tower - Calgary Cancer Centre - Edmonton Valley Line LRT
Prairies (Manitoba, Saskatchewan)	No provincial mandates or guidelines	Winnipeg BIM Community SaskBIM	- Manitoba Hydro Spillway Replacement - Winnipeg Investors Group Field - Canadian Museum for Human Rights - Jim Pattison Children's Hospital of Saskatchewan
Ontario	- No provincial mandate - Metrolinx has BIM requirements	Toronto BIM Community (tBIMc)	- Ontario Line - KING Toronto - Humber River Hospital - York University's Second Student Centre
Quebec	- Provincial BIM roadmap (2021-2026) endorsed by the Treasury bord of Quebec - BIM mandated on all projects over 10M$ by the Société Québécoise des Infrastructures - BIM mandated on all building projects over 2M$ by the City of Quebec. - BIM mandates under development for the Ministry of transports and sustainable mobility, Hydro-Quebec, the City of Montreal and additional public owners to be announced - Quebec Construction 4.0 Initiative aimed at accompanying over 800 companies in the Quebec construction industry to develop and implement a digital adoption plan	Groupe BIM du Québec	- Quebec city amphitheater - NCH Hospital in Quebec city - CHUM Hospital in Montreal - Reseau Électrique Métropolitain (REM) - Champlain Bridge - Olympic Stadium Tower - Multiple primary and secondary schools across the province - Multiple assisted living centers across the province
Atlantic Provinces	No provincial mandates or guidelines	Coming soon	Collaborative Health Education Building (Nova Scotia)
Territories	No provincial mandates or guidelines		
National	Governments working groups in progress	building SMART Canada	buildingSMART International Awards

Key Findings and Insights from BIM Readiness Assessment

BIM represents a modernization of construction and project management processes and a fundamental shift towards greater efficiency, collaboration, and data-driven decision-making in the architecture, engineering, construction, owner, operator, and manager (AECOOM) sectors. Throughout this report, we have identified key insights and considerations that should facilitate increasing BIM adoption and implementation in Canada, as summarized below:

The analysis undertaken reveals several pivotal findings. The findings suggest a shift towards digitalization in the industry, with organizations actively embracing digital deliverables, transitioning from unmanaged to managed CAD workflows, and employing managed 3D environments. The existence of contractual mandates for BIM processes and digital deliverables underscores industry recognition of the benefits of BIM.

However, it is also evident that ISO 19650 adoption remains relatively low. Challenges associated with the standard's alignment with the Canadian industry, front-loading efforts required for adoption, and the complexity of terminology and file naming conventions need to be addressed. In addition, information management policies require further refinement.

Enablers for successful BIM integration include enhanced efficiency through close collaboration with consultants, risk mitigation, and stakeholder-driven momentum. In contrast, barriers such as collaboration challenges, resistance to change, and a lack of in-house expertise persist. Bridging the knowledge gap and focusing on process improvements are pivotal for successful implementation.

Government Mandates and Leadership:
The findings of this report suggest resounding industry support for regulatory government mandates for planning approvals, building permits, and owner submissions. While mandates may pose challenges, they can help to drive standardization and improve data consistency. The findings suggest advocating for a collaborative approach, phased implementation, and continuous engagement with industry stakeholders to ensure successful implementation.

Effective owner leadership, both in the public and private sectors, is pivotal in BIM implementation. Owners can advocate for platform agnosticism, focusing on "what" needs to be achieved rather than prescribing "how" to do it. Government leaders can support BIM mandates by investing in owner education, establishing resource directories, offering financial support, and fostering collaborative forums.

Next Steps and Implementation: The findings suggest a phased approach to BIM adoption and mandates creation, with a focus on stakeholder engagement and educating the industry. Initiatives to enhance awareness, conduct cost-benefit analyses, and ensure access to standardized documentation are vital for owners and government bodies. Implementation should be guided by a culture of accountability and a recognition that BIM's utility extends well beyond the design and construction phases.

Part 3:

A BIM Roadmap for the Canadian Built Environment - Final Recommendations

A Roadmap to Lifecycle BIM in the Canadian AECOOM Community

The built asset industry in Canada is poised at a critical juncture where digital transformation is essential to enhance its efficacy and its role in social, environmental, and economic progress. This necessitates a shift towards more integrative methods of project execution, employing BIM tools, technologies, openBIM standards and methodologies. These changes should be in harmony with worldwide efforts in the same direction. Recognizing this imperative, we have formulated a comprehensive BIM roadmap.

This roadmap is designed to initiate, direct, and maintain the momentum of this digital shift, ensuring that the built asset industry in Canada not only keeps pace with global trends but also sets new standards in innovation and sustainability.

We strongly believe that a transformation to collaborative BIM-based project delivery and lifecycle processes in the Canadian AECOO community must be founded on six principles:

1. All Canadian AECOO community stakeholders, at all levels, must be actively **engaged** in the transformation;

2. The technologies, processes and standards supporting the transformation must be rigorously, consistently and continually **developed** and maintained;

3. All Canadian AECOO community stakeholders must be **educated** and trained to ensure the transformation be successful and maintained;

4. The tools, technology and processes that are developed must be **deployed** and adopted within a conducive environment across the Canadian AECOO community;

5. The progression of this transformation must be continuously monitored and **evaluated** for effectiveness;

6. The transformation must be **sustained** by all Canadian AECOO community stakeholders well beyond the initial transformation cycle.

A Call to Action

The roadmap articulates these six principles and develops them by setting clear milestones aimed towards a verifiable desired state. bSC is convinced that the roadmap will facilitate the transformation to a better performing industry through the collective participation of all its stakeholders. We challenge the Canadian AECOO community to get involved and support this roadmap. participate in its implementation, and put its outcomes into practice.

The developed roadmap is a a call to action to engage the AECOO community. faster consensus, and move towards openBIM-based solutions. It is a living document with the following outcomes:

- a National BIM mandate that sets out the framework (technological, organizational, and procedural) for the deployment of collaborative BIM-based project delivery environments in the Canadian AECOO community.
- An alignment between all stakeholders with regards to roles and impact in supporting and sustaining this collective transformation; and
- a clear scope and sequence of activities that must be carried out in order to support and sustain this collective transformation and progress towards a desired state
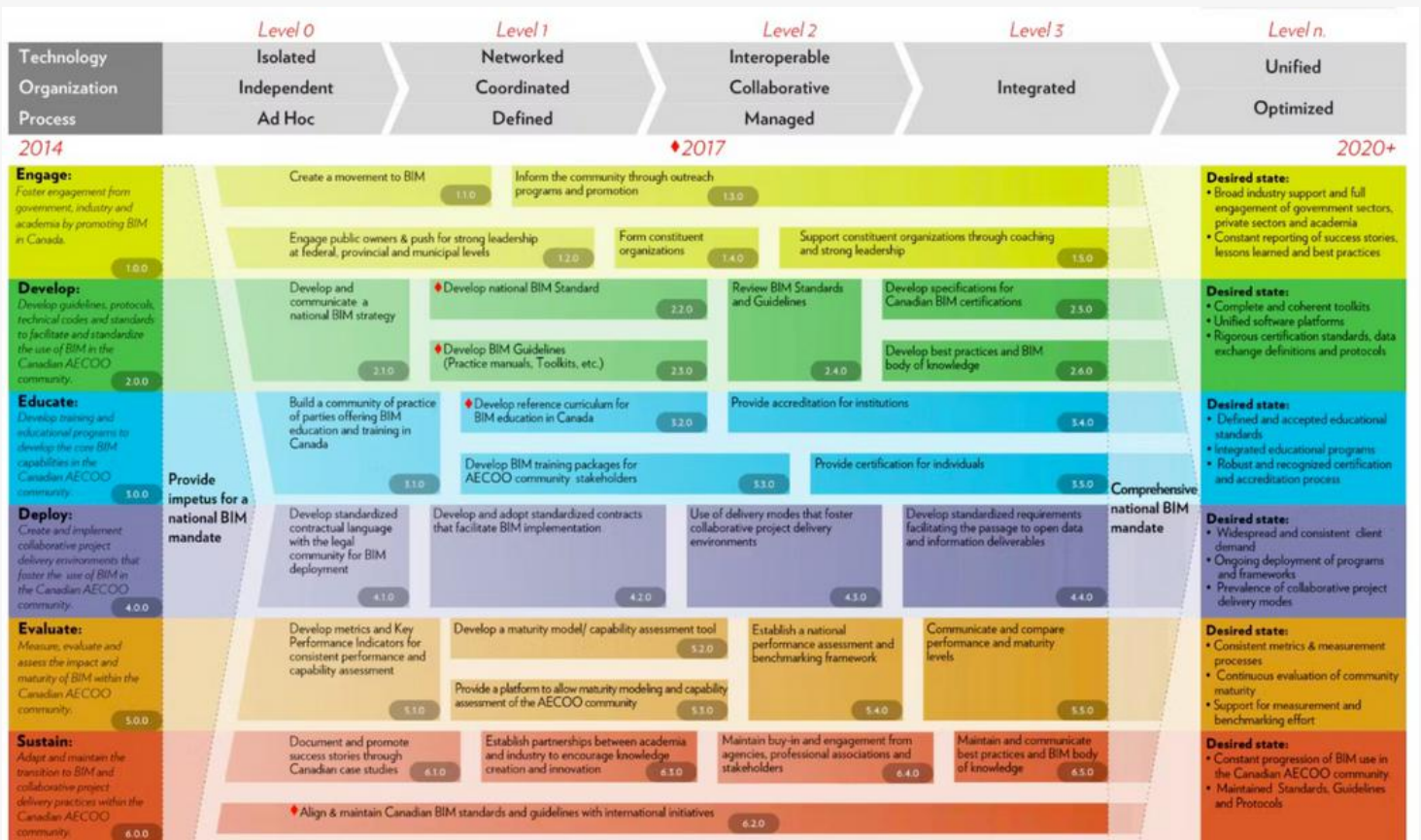

Figure 65. A Roadmap to Lifecycle BIM in the Canadian AECOO Community

Towards a "Meta"- Roadmap

Building upon the outlined visions in the developed National BIM Roadmap, a "meta-roadmap" is a strategic framework aimed at guiding the Canadian AECOO industry towards a unified and effective digital transformation. This framework is crucial for several reasons. Firstly, it lays the foundation for a shared vision of digitalization across the industry, ensuring that all stakeholders are moving towards the same objectives. By doing so, it maximizes the benefits of openBIM standards and interoperability requirements, enhancing efficiency and innovation. Additionally, this approach is designed to prevent the wasteful repetition of efforts and the overburdening of stakeholders, which often occurs when multiple, uncoordinated initiatives are undertaken simultaneously.

A significant aspect of this framework is its focus on pooling resources. The AECOO industry, characterized by its limited resources, stands to gain substantially from a consolidated approach that amplifies the impact of these resources. Finally, the framework addresses the issue of fragmentation in standards, guidelines, and resources. By advocating for a unified approach, it aims to eliminate the confusion and inefficiencies brought about by multiple, competing standards. This comprehensive strategy not only streamlines the process of digital transformation but also positions the Canadian AECOO industry as a leader in sustainable and technologically advanced practices.
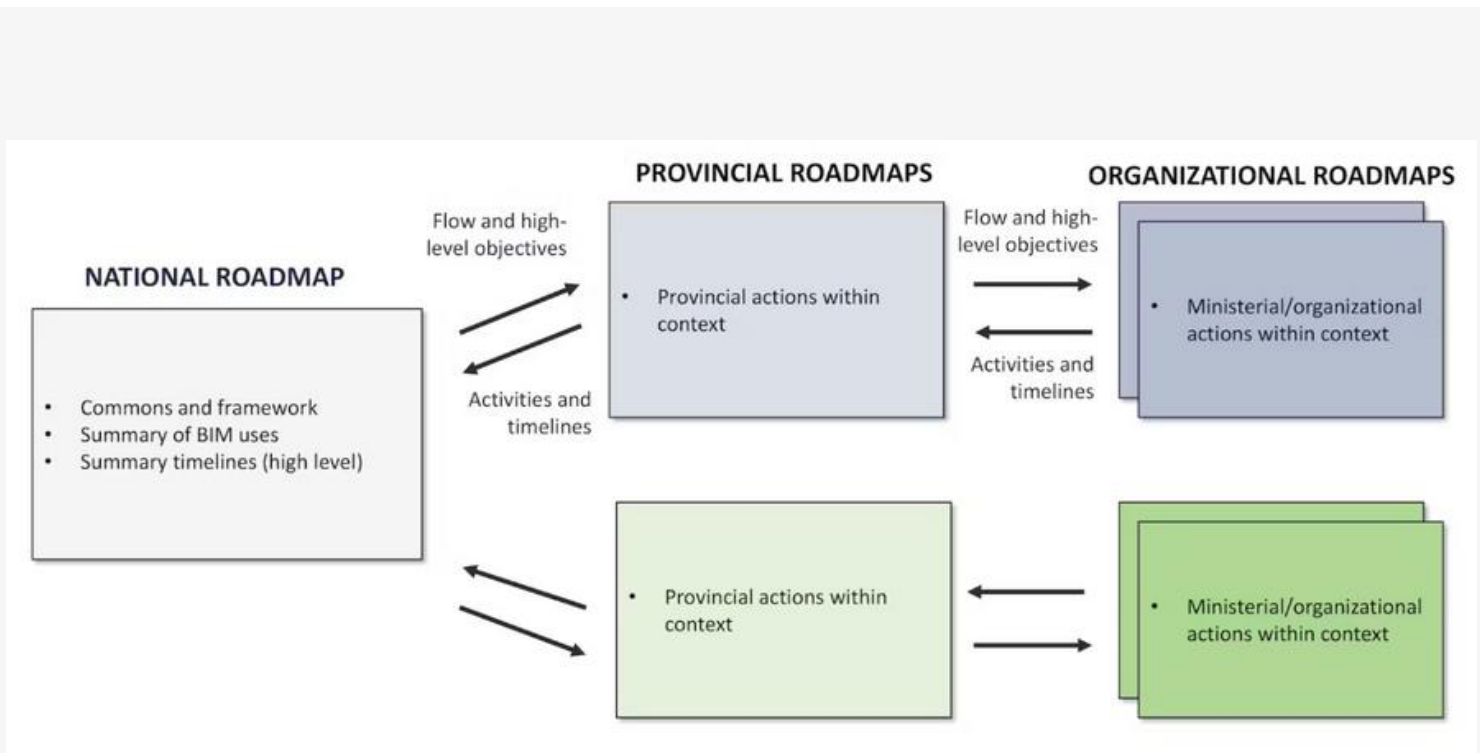

Figure 66. A framework to integrate provincial and organizational roadmaps into a meta-roadmap

Final Recommendations

As we reflect on the dynamic and insightful workshop held during the bSC National Summit in November 2023, it is imperative to underscore its main role in shaping the future of BIM and openBIM solutions in Canada. This workshop, a cornerstone of the summit, brought together a diverse group of stakeholders and industry experts, each bringing a unique perspective and expertise to the table. The primary objective of this workshop was to gather practical, innovative, and forward-thinking recommendations regarding the various principles of the developed National BIM Roadmap.

Participants engaged in thoughtful discussions, brainstorming sessions, and collaborative exercises, all geared towards identifying actionable strategies that could facilitate implementation of the roadmap. The workshop was structured to ensure comprehensive coverage of all key areas of the BIM roadmap. These included, but were not limited to advancements in:

- Engagement activities
- Development activities
- Education activities
- Deployment activities
- Evaluation activities
- Sustainment activities

The following figures represent the collective vision and commitment of Canada's leading BIM professionals and stakeholders. They are a testament to what we can achieve when we come together, share our knowledge, and work towards a common goal.

- How advanced are **engagement** activities?

Very far behind ... Very advanced

- Creating a movement to BIM. — 2.4
- Engaging public owners and push for strong leadership at federal, provincial and municipal levels — 1.9
- Informing the community through outreach programs and promotion. — 2.1
- Forming constituent organizations. — 2.5
- Supporting constituent organizations through coaching and strong leadership — 2

- How advanced are **development** activities?

Very far behind ... Very advanced

- Development and communication of a national BIM strategy. — 1.7
- Development of a national BIM Standard — 1.6
- Development of BIM guidelines (practice manuals, toolkits, etc.) — 1.9
- Reviewing BIM Standards and guidelines. — 2
- Development of specifications for Canadian BIM certifications. — 1.7
- Development of best practices and BIM body of knowledge. — 1.7

- How advanced are **education** activities?

Very far behind ... Very advanced

- Building a community of practice offering BIM education and training in Canada. — 2.1
- Development of a reference curriculum for BIM education in Canada. — 1.9
- Development of a BIM training packages for AECOO community stakeholders. — 1.8
- Providing accreditation for institutions. — 1.5
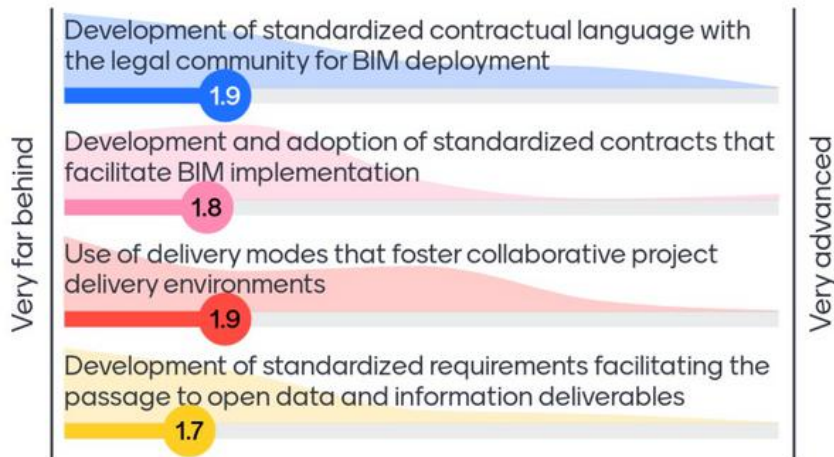- Providing certification for individuals. — 1.8
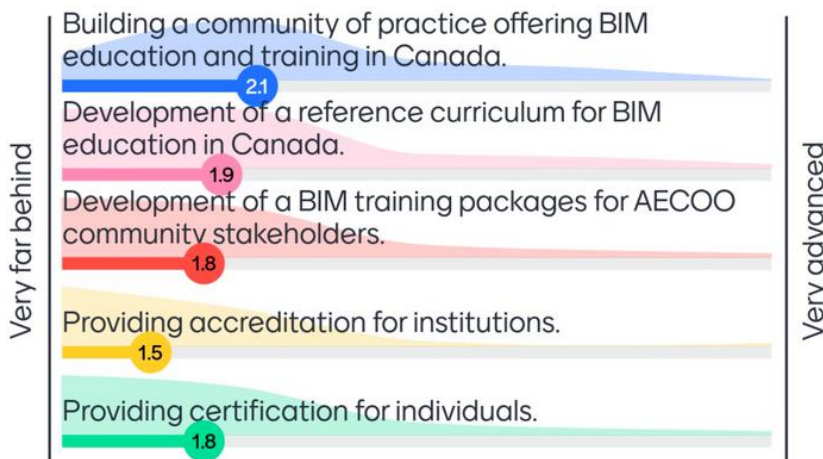
- How advanced are **deployment** activities?

- How advanced are **evaluation** activities?
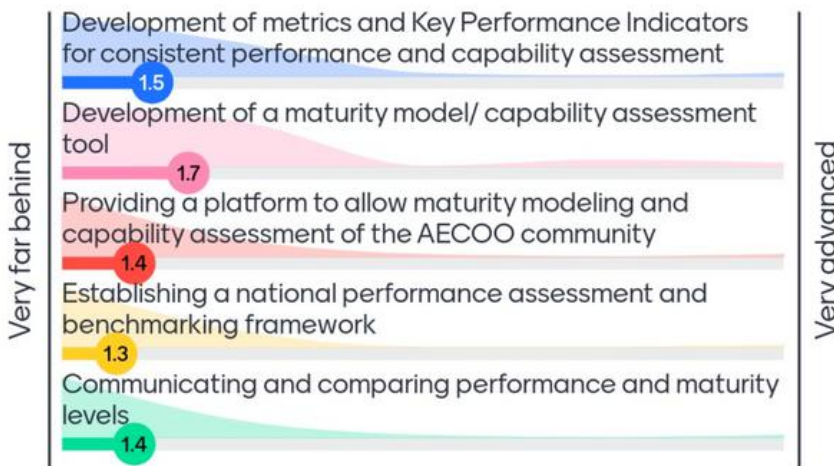
- How advanced are **sustainment** activities?

To effectively address shortcomings outlined in the above figures, bSC acts as a conduit for international best practices, effectively bridging the gap between international innovations and national implementation. Through fostering collaborative relationships among industry leaders, government bodies, and academic institutions, bSC is dedicated to propelling Canada forward. This collaborative approach ensures that the nation stays at the forefront of technological advancements and sustainable practices in the construction and infrastructure sectors, aligning with global standards and contributing to the industry's overall growth and efficiency.

Ackowledgements

We are grateful to the following organizations and associations for their valuable input and expertise in this industry readiness assessment.

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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.

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