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STRUCTURING THE ADOPTION AND IMPLEMENTATION OF BIM AND INTEGRATED APPROACHES TO PROJECT DELIVERY ACROSS THE CANADIAN AECO INDUSTRY: KEY DRIVERS FROM ABROAD

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Abstract: The architecture, engineering, construction and owners (AECO) industry plays a vital role in a country's economy, and has a great impact on its society and on the local and global environment. Focussing on the performance and the impact of their respective AECO industries, government bodies around the world are increasingly pushing to transform current practices to maximise the value generated by this industry. Recent innovative approaches, notably building information modeling (BIM), integrated approaches (either integrated project delivery (IPD) or integrated design processes (IDP)) and Lean construction, show promise in providing many improvements. However, many challenges and obstacles are hindering the deployment of these approaches; a lack of strong client demand chiefly among them. In response to this, many countries have developed strategies to encourage and accelerate the pace of adoption of these innovative approaches. This often is prompted by requirements for suppliers to implement one or more of these innovations on all their publicly procured projects. The various levels of governments in Canada however have yet to follow suit in this regard. As a consequence, the Canadian AECO industry is seen to be lagging in its adoption of BIM and integrated approaches to project delivery. While certain projects have emerged as beacons of enlightened practice in the Canadian context, it remains that the vast majority of projects are still being delivered in a traditional fashion, with the well-known limitations this entails. This paper investigates the contextual challenges in adoption and implementation of BIM and integrated approaches in the Canadian AECO industry. The objective is to identify challenges and opportunities to create favourable context that ensures that the Canadian AECO industry remain competitive in the face of increasing global competition by leveraging the potential significant benefits of these innovative approaches. This paper is based on a review of the literature of various initiatives around the world. The paper lays out six key factors, which are seen as drivers for the adoption and implementation of BIM and integrated approaches in other countries, and discusses their implication in the Canadian context. Notably, the need for a national policy that structures the adoption and implementation BIM and integrated approaches; the need for leadership from the public sector; the importance of constituent organizations acting as a voice for industry; and the need for investments in research and development.

1 INTRODUCTION

The Canadian architecture, engineering, construction and owners (AECO) industry represented $290 G in capital expenditure in 2013, approximately 20% of the Canadian GDP (Statistics Canada, 2014). Moreover, the construction industry alone employed 1.3 million people or 7.5% of total workforce during this same period (OECD, 2014) distributed across more than 120 000 enterprises (Industry Canada,

2014). As with most countries, the Canadian AECO industry is truly one of the pillars of the Canadian economy, generating significant value for its society. On the other hand, it must contend with many well-known obstacles, such as its fragmentation and complexity which make it a wasteful and inefficient industry. In fact, many countries have invested and put forth national frameworks and initiatives to support the reform of their respective AECO industries to improve performance, productivity and the value that is generated. Over the past two decades, innovative tools, technologies and processes for project delivery and asset lifecycle operations and maintenance, such as building information modelling (BIM), integrated project delivery (IPD), integrated design processes (IDP) and Lean construction have shown much promise in helping the industry overcome these obstacles and shortcomings. These innovative approaches have been adopted and their development made a priority in many countries around the globe. The Canadian AECO industry, however, has yet to initiate this transition. Indeed, there is a general consensus that it is lagging behind many of these other countries in the adoption and implementation of these innovative approaches (Beaudoin et al., 2011). In the current global economic context and facing increasing global competitive pressure, the Canadian AECO industry, cannot afford to stand idle and let pass the opportunities to transform itself through a structured and strategic reform. On the other hand, this relative tardiness can also been seen as a serious advantage in that the industry can learn from other countries and avoid many of the growing pains that others had to go through. In this regard, this paper seeks to answer the following questions:

1. How can the Canadian AECO industry learn from other countries' experiences in the transition to innovative project delivery approaches?
2. In light of these lessons learned, how can the Canadian AECO industry develop a comprehensive reform strategy in order to improve its performance and efficiency to ensure its sustainability and competitiveness?

The paper first gives a brief overview of the current innovative approaches to project delivery that are being developed around the globe. It then exposes the particularities of the Canadian AECO industry context and discusses the adoption and implementation of these innovative approaches for the Canadian AECO industry across six key factors that were developed by Wong et al. (2010). A comparative analysis between Canadian initiatives (or lack thereof) and various from around the world is performed. Lastly, the paper concludes with a discussion on moving forward with a national framework for the adoption and implementation of innovative approaches to project delivery.

2 THE TRANSITION TO BIM AND INTEGRATED APPROACHES

The past decade has seen a rapid growth in the literature, both academic and industry oriented, pertaining to BIM implementation and the deployment of innovative project delivery approaches. These approaches are seen as a solution to target fragmentation and inefficiency of the AECO industry. BIM is perceived as both "Technology" and "Process". BIM technologies allow to prototype a product, where a *building information model* is constructed with input of precise digital data to support the design, procurement, fabrication and construction (Eastman et al., 2011). This innovation changes the roles and relationships of all the stakeholders involved in the project delivery process, demanding new ways of work, thinking models and approaches to design and construction. However, BIM adds even more value to the project delivery if it is supported by the integrated design and construction approaches (Eastman et al., 2011) as well as by Lean construction approaches. These integrated approaches are "*A holistic approach to building in which all project stakeholders and participants work in highly collaborative relationships throughout the complete facility life cycle to achieve effective and efficient building"* (Elvin, 2007). Among the major initiatives regarding the integrated approaches, two main approaches could be distinguished: Integrated Design Process (IDP), which seeks energy optimization and sustainable design; and the Integrated Project Delivery (IPD), which focuses on the optimization of the project delivery process by reducing waste and managing project information flows in integrated way. In an integrated approach, the most important decisions are taken in the early stages of project design process. These decisions have a major impact not only on the progress of the construction phase, but also on the asset's lifecycle. Lean Construction is a new way of managing projects that look to minimize waste and time, and to maximize value (Ballard, 2000). This approach is considered an optimal solution for managing various project delivery processes, and for taking full advantages of BIM, while maximizing their benefits. BIM is seen as a 'tool' to support integrated relational contracts such as Integrated Project Delivery (IPD),

alliancing or Integrated Supply Chain, enabling a tighter collaboration, where the process becomes more efficient and predictable. BIM decisions and protocols are best developed by joint decisions in IPD process that maintains the beneficial relationships between parties (AIA, 2007). Also, many researchers and studies recommended combining Lean with BIM to create a positive team synergy, which generates a great opportunity for improvement in industry (HM Government, 2012, Sacks et al., 2010).These in turn improve efficiency, knowledge dissemination, reduce errors, and enable generation of alternative solutions and expansions of market opportunities. Implementing integrated approach and collaboration with BIM brings more value to the process.

In an attempt to move towards a more efficient AECO industry, several countries have undertaken the reform of this industry by setting up initiatives which promote the adoption of one or more of these innovative approaches. Wong et al. (2010) carried out an extensive review of initiatives targeting BIM implementation from around the globe. The authors performed an overview of these initiatives in the USA, Finland, Norway, Denmark, Singapore and Hong Kong in terms of policy, process and technology. Their study identified some attributes which are seen as strategic steps taken to implement BIM in these countries: 1) The importance of the public sector as a driver for implementation of BIM in all the countries studied; 2) Establishing clear and specific governmental policy mandating BIM on all public projects; 3) Developing standards and guidelines for the deployment of BIM; 4) Clear information exchange capability requirements, and relying on open standards for data and information exchanges; 5) Designated organizations responsible for BIM implementation within a country (either an existing government department or external organization); 6) A constant and consistent reporting and promotion of BIM; 7) A focus on BIM research and the establishment of BIM research programmes. In the 5 years since the paper was published many more countries have sought to establish BIM initiatives, namely the United Kingdom (UK), Australia, New Zealand, France, Brazil and Korea. An analysis of these international initiatives reveals that the successful deployment of the innovative approaches depends largely on strong leadership from the government in the form of interventions and targeted initiatives, and commitment of governments to direct or support these initiatives. To better support this reform, some countries have rethought the structure of their industry by setting an overarching strategy which includes procurement methods, and an integration between government and industry stakeholders and promotes collaborative work, such as in the UK. Other countries have worked closely with the industry by offering financial incentives, and academic support programs such as in Singapore. The technological advancement to promote innovation was a key driver in the Scandinavian countries. While seeking performance and productivity improvement was a key driver in the US. All these countries have developed strategies, set specific milestones, and took considerable action to achieve their goals. To date, some benefits have been observed, many challenges have been encountered and there is still work to do to achieve their ultimate goals. Canada can learn from these initiatives to inform and structure its transition to innovative project delivery approaches.

3 THE CANADIAN CONTEXT

The Canadian AECO industry plays an important role in the Canadian economy, influences Canadian society and has a major impact on its environment. However, the context in which the Canadian AECO industry evolves is very particular. First, the AECO industry is based on provincial jurisdiction. As such construction projects are governed by provincial laws with the exception of federal projects (military, federal infrastructure such as certain bridges, airports, sea ports and projects for First Nations communities). These laws vary between provinces, especially in Quebec, which is subject to the Civil Code. The Canadian AECO industry is also very diverse; each province has its own professional associations, which govern all aspects related to professional accreditation and certification. Furthermore, there is a lack of industry-wide organizations to support innovation in Canada as discussed by Froese and Rankin (2009). This particular context makes it difficult to establish comprehensive initiatives that are consistent across the country, and can be endorsed by various levels of government as well as the public sector. For example, the National Benchmarking Initiative initiated by the Canadian Construction Innovation Council (CCIC) (Rankin et al., 2008) was discontinued when the CCIC was closed due to a lack of funding. The Canadian Construction Innovations (CCI) was created in 2013 to fill the void. This particular context also influences the speed of innovation, namely in adopting new technologies and approaches.

Little empirical work has looked into the adoption of integrated approaches and BIM in the Canadian AECO industry. As such, actual adoption rates in Canada are still largely unknown. However, there has been more attempts at quantifying the BIM adoption rate in Canada. In this regard, various surveys have been conducted over the past 6 years. The principal sources of data are the McGraw-Hill surveys (2009, 2012 and 2014) that showed a 49% BIM adoption rate in Canada in 2009, which grew to a 72% adoption rate in 2012. These results were on par with adoption rates in the US (McGraw Hill Construction, 2012). Recently, McGraw Hill Construction (2014) published results of a new survey presenting BIM adoption by contractors around the world. The report shows that 87% of Canadian contractors have adopted BIM, and that most report a positive return of investment. Again, this report still considers Canada and USA on par in terms of BIM maturity. The results of these studies are limited mainly due to the small sample size: 175 respondents from Canada compared to 2,053 from the US in 2009, 29 respondents from Canada compared to 553 from the US in 2012, and 39 respondents compared to 291 respondents in the US in 2014. In a similar study, carried out by NBS (2013), four countries took part in a survey measuring BIM adoption rates: Canada, UK, Finland and New Zealand. The survey indicated that 64% of Canadian respondents (78 respondents) were aware of and were using BIM, compared to 65% (more than 400 respondents) in Finland, where BIM is obligatory for public projects since 2010. The author of the study highlights the fact that for all the countries except Canada, the confidence rate was high and that the data was largely representative of the respective industries. For Canada, however, the results of the survey may have been skewed by the fact that the respondents were likely to be people that were familiar with BIM instead of an accurate statistical representation of the Canadian AECO industry. Other work looking into BIM adoption in the Canadian AECO industry has found that BIM implementation in Canada is currently being led by the industry and by looking at what is happening in the US. In this regard, Forgues and Staub-French (2011) have conducted a study comparing the adoption of BIM between early adopters in the Canadian AECO industry and BIM users in the American one. They observed important gaps between these two industries. The main gap noted was that the overall level of use of BIM tools on projects was systematically lower in the Canadian industry than in the U.S. industry. This study showed that BIM adoption in the U.S. industry was more advanced, and discussed how BIM implementation is related to market demand, particularly on the part of the client. To close the gap, the study argued that the transition to BIM would have to be endorsed by public clients, and that support from research and professional associations is critical. In other words, specific drivers were needed to provide impetus for widespread BIM adoption and implementation in the Canadian AECO industry.

4 KEY DRIVERS FOR CANADA

Specific attributes, also seen as drivers, for widespread adoption and implementation of BIM, and to a certain extent other innovative project delivery approaches, at the national level have been developed by Wong et al. (2010). Using those specific drivers, we discuss the implications for the Canadian AECO industry and compare them to what has been done elsewhere.

4.1 Public Sector As A Driver

Better satisfying client requirements and improving asset management has led various public organisms to look into the use of innovative project delivery approaches. Namely, the *United States Government Services Agency* (GSA), *Statsbygg*, the Norwegian Directorate of Public Construction and Property, and Senate Properties, the Finnish state owned enterprise responsible for real property acquisition and maintenance, and Her Majesty's Government in UK have acted as drivers for innovation in their respective AECO industries by taking active steps in pushing for the widespread use of BIM and integrated approaches on their public projects. One of the most telling examples is that of the GSA who since 2003, has established a program to develop BIM guidelines to better meet and deliver its clients space requirements. Between 2003 and 2006, the (GSA) carried out 9 pilot projects to test and develop BIM implementation for various uses. This allowed the GSA to develop its 3D-4D BIM program and the accompanying guides. During that same period, the Danish government initiated *Det Digitale Byggeri* (Digital Construction) (bips, 2011), a public-private initiative, aimed at providing a number of requirements governing the use of BIM and ICT for consultants and contractors (The European e-Business Market Watch, 2005). While the Danish government does not possess a large property portfolio, its support of the

transition to innovative approaches has had a strong impact in the Danish AECO industry and can continue to do so. For instance, the report of COWI (2009) demonstrated that by developing projects in a fully digital environment, this would contribute an additional € 2,3 billion per year to the Danish economy. Lastly, the UK has a long history of questioning the practices of its AECO industry and developing programs to overcome the limitations of this industry, the most famous being the Latham and Egan reports (Latham, 1994, Egan, 1998). More recently, the government has set aggressive targets in their *Construction 2025* industrial strategy*:* 33% lower costs, 50% faster delivery, 50% lower greenhouse gas emissions and 50% improvement in exports (HM Government, 2012). Further to these telling examples of public sector leadership, one of the main lessons learned from the exploration of innovative approaches around the globe is that successful implementation has been supported by investment from the governments either for research and development (such as in Finland and Norway) or to support the industry (such as in the UK). A specific example of this is the Singaporean government who has introduced the BIM Fund that covers training, consultancy services, purchase of software and hardware. Other investments by the public sector are illustrated in table 1.

Table 1: Investment in BIM implementation per country

Country	Organization	Investment
United Kingdom	BIM Task Group	Public sector funding Mobilisation - £ 1.4 million Operations – £ 480 000 / year (5 years) Total – £ 3.86 million ($ 6.94 million CAN)
Finland	Tekes	Public and private sector funding Pre program at RYM oy. R & D – € 21.7 million (4 years between 2010 and 2014) ($ 30.9 million CAN)
Norway	Statsbygg	Public and private sector funding R & D – € 21.7 million (4 years between 2010 and 2014) ($ 30.9 million CAN)
Singapore	Building Construction Authority (BCA)	Public sector funding BIM fund – cover up to 50% of costs associated to BIM adoption within firms: 12 millions SGD ($ 10.4 millions CAN)

As mentioned, the Canadian government has put forth some initiatives targeting the AECO industry. However these have either been short lived or their impact has not been fully felt. When looking at other countries, most of these initiatives were undertaken within a specific government department and treated as a priority within this department. These countries have recognized the significant power of the public sector as a key actor in the reform of the AECO industry. In this regard, the Canadian public sector represents 22.40% of the total capital expenditures in Canada, or $ 65.18 B (Statistics Canada, 2014). These capital expenditures are distributed across three levels of government. At the national level, public bodies include: Public Works and Government Services Canada (PWGSC), the Department of National Defense (DND), and its representative Defense Construction Canada (DCC). At the provincial level, each government has a specific organization, a crown corporation, which assists other government agencies in their construction projects and asset management. Lastly, at the municipal level, most large municipalities will have departments responsible for overseeing construction projects. It is also at the municipal level that building codes and bylaws will be enforced through development applications, public consultation and plan review. The complexity inherent to this multi-layered governmental context is a core issue to the lack of national initiatives that can truly take root in the Canadian AECO industry. The authors believe that while a national initiative is relevant, the bulk of the work must happen at the provincial and municipal levels. Therefore, this national framework for innovative project delivery must be multi-tiered and consistently adopted and adapted at all three levels of government.

4.2 Governmental Policy Mandating BIM on All Public Projects

The principal way through which the countries mentioned above have driven the adoption and implementation of innovative project delivery approaches, namely BIM, has been through a national

policy mandating their use on all public projects. For example, the US, Finnish and Danish governments have all been mandating BIM on all public projects since 2007. The Norwegian government has stated its commitment to succeed in BIM adoption in 2010 (The BIM Issue, 2011). Both Hong Kong and Singapore are making BIM obligatory in 2015, while the UK government is mandating "level 2" BIM, or a "managed 3D environment held in separate discipline "BIM(M)" tools with attached data" on all its projects in 2016 (BIM Task Group, 2012). No such timeline exists in Canada either at the national, provincial or municipal level. While there exists no formal policy mandating BIM implementation on all public projects in Canada, several governmental bodies, at varying levels, have initiated pilot projects to begin framing a mandate. In this regard, the authors are aware of four separate initiatives where BIM is being looked into by a government body: The work in the field of space management and open BIM initiated by DND and DCC since 2009, the Royal Alberta Museum pilot project initiated by Alberta Infrastructure, several small pilot projects initiated by the Société Immobilière du Québec (SQI) and finally, the Moose Jaw Hospital initiated by the Government of Saskatchewan, which incorporated BIM and more importantly is one of the first IPD contracts with lean approach in Canada. These individual efforts across Canada show a willingness on the part of governmental bodies to move towards these innovative project delivery approaches. However, there is a risk that these individual efforts lead to fragmented policies across the county. There is a need for a concerted effort across all levels of government, to develop a unified mandate regarding the implementation of BIM and other approaches on public projects.

4.3 BIM Standards and Guidelines

The number of BIM standards and guidelines has grown exponentially over the past years. Representatives from both the US and the UK have mentioned that the presence of so many different standards was problematic in broadcasting a consistent message and gaining traction within the industry. In particular, the US is faced with the challenge of having many different standards, which have been produced, at the National level (GSA, US Army Corp of engineers, US Veteran, US Coastguard), at the state level, at the municipal level and from private owners (ie. universities). The presence of so many guidelines and standards has created confusion in the US industry, namely with the professionals who have to contend with these different standards. On the other hand, the Finnish, Norwegian, Danish and Singaporean examples are particularly interesting in their strategy of developing standards from a single source, with inputs from industry, academia and government. For example, Senate Properties in collaboration with buildingSMART Finland, construction companies, big cities, hospitals and consulting companies produced their BIM requirements in 2007 and updated them in 2012 (COBiM, 2012). In Denmark, bips is responsible for the producing the Digital Building Code and the Danish Building Classification System (DBK) based on buildingSMART. The Building Construction Authority (BCA) is the sole source of BIM standards in Singapore.

Canada has a big advantage to benefit from the efforts and lessons learned of other countries in developing its standards. Some guidelines have begun to appear, namely the AEC (Can) BIM Protocol published by the Canadian BIM Council (CanBIM) and modeled on the AEC(UK) BIM protocol, developed by the AEC(UK) initiative. These protocols serve as tools to generically inform model structure and the modeling process, and have not been adopted as a governing standard by either the Canadian or the UK industries. The Institute for BIM in Canada (IBC) has published a series of 'toolkits' aimed at supporting the implementation of BIM by Canadian firms (IBC BIM, 2014). IBC has also published a contract language document to be used as an exhibit or appendix to other contracts and spells out the roles and responsibilities as well as the uses of BIM on the project. While these documents serve to better inform the implementation of BIM in Canada, they have not yet been endorsed by any governmental bodies. There are other efforts to create national standards in Canada, notably, the Canadian Construction Documents Committee (CCDC), a national joint committee responsible for the development, production and review of standard Canadian construction contracts, forms and guides, and the National Building Code of Canada (NBCC), issued by the Institute for Research in Construction (IRC), which is part of the National Research Council of Canada (NRC). Whereas, the standard contract documents produced by CCDC are now widely used by the Canadian AECO industry, they still are used on a project basis. On the other hand, the model code produced by the IRC must be adopted by a jurisdiction to take effect. Many provincial jurisdictions have adopted the NBCC as is. Some provincial and even municipal jurisdictions have modified the NBCC, as is the case in British-Colombia, Quebec and in the city of Vancouver.

However, they possess the same structure and much of the same content. In light of these efforts, there is potential for the creation of unified standards and guidelines for the Canadian AECO industry. While these standards could be informed by existing standards such as versions 1 and 2 of the National BIM Standard, produced by the NIBS, as well as the Common BIM Requirements produced in Finland, these standards could be endorsed at all government levels, similarly to the National Building Code. Furthermore, they should be consensus based and originate from a unique organization that is comprised from members of industry, academia and government.

4.4 Clear Information Exchange Requirements and Open Standards

One of the core concepts of BIM is the seamless production and exchange of information across a project's lifecycle (Eastman et al., 2011). In an effort to ensure this seamless information flow, open exchange standards are critical so as to not be reliant on a specific platform or proprietary mechanism. These open standards have been developed over the past two decades, namely the Industry Foundation Classes (IFC) by buildingSMART international (formerly the International Alliance for Interoperability (IAI)). Recognizing the importance of this open data exchange, the GSA, Senate Properties, Statsbygg and DECA (Denmark) signed a joint statement in 2008 to support open BIM based on IFC (Winstead et al., 2008). The question of data requirements is more complex. What information is to be produced at what time and for what use is a difficult question to answer; it is highly dependent on the stakeholder's perspective. From a public owner's perspective, two perspectives emerged from the various initiatives around the world. The first is for specific uses such as program validation (GSA) or code compliance checking (Singapore). The second is to ensure the reuse of information over the product lifecycle. In this case, the standards indicate how the information should be input to ensure consistency across projects, as is the case in the Finnish and Danish standards. Lastly, the question of information evolution has been addressed by the UK government who has developed COBie drops to allow public owners to validate the information received from their project team in a structured manner (The National BIM Library, 2012).

Canada can benefit from the development and work in this field performed in other countries. While the mandating of IFC compliant deliverables on public projects is relatively straightforward and the international consensus around the use of this exchange standard provides relative stability and confidence, the exchange requirements will have to be further investigated. While government bodies can look to these requirements to fulfill their business processes, they should also look to leverage these them in order to prompt the reconfiguration of practice that is called for in the transition to BIM and integrated approaches. In other words, while the value of this open data for public bodies lies in its reuse over their asset's lifecycle, in their role as catalysts for change, these public bodies should look at structuring the information requirements to push project teams to innovate and become more efficient.

4.5 Designated Organizations Responsible for BIM Implementation

Further to the development of standards and guidelines originating from a single source, an organization responsible for driving BIM adoption and implementation in Canada should be mandated. This has been the case in other countries such as the *BIM Task Group, a UK Government-funded group,* which plays an active role in the reform at the national level by helping the AECO industry become more efficient and to adopt collaborative work practices for all public projects. Although the group has a small number of personnel (10 people), they work on creating links between industry, government, public sector and academia around collaborative work and BIM; and on developing open standards to facilitate interoperability and data exchange to reduce barriers in this exchange (HM Government, 2012). Another example is the *BCA* in Singapore who is primarily responsible for the implementation of BIM and integrated approaches within the Singaporean AECO industry, more specifically, introducing BIM Fund incentives as mentioned earlier.

The role of professional associations in the deployment of BIM is very important. In the US and the UK, professional accreditation is done through national bodies such as the American Institute of Architects (AIA) and the Royal Institute of British Architects (RIBA). This results in a very large constituent base for these associations. Both the AIA and RIBA have been instrumental in advocating and developing tools for the implementation of BIM and IPD in their respective countries. The same can be said for the

Association of General Contractors (AGC) in the US. In Canada, construction being of provincial jurisdiction, professional accreditation becomes the responsibility of provincial associations. This reduces the capability to understand and support changes in the professional practices and body of knowledge at the same time. Some associations, such as the Royal Architecture Institute of Canada (RAIC), Engineers Canada (EC) and the Canadian Construction Association (CCA) operate at the national level and assist provincial bodies in terms of certification of education. However, they mainly serve as advocacy groups and hold little power over day to day practice, contrary to their American and British counterparts. This limits the impact of national initiative put forth through professional associations. To push a national mandate for BIM and integrated approaches, it will be important to get all professional associations to support and buy into the initiative. Lastly, two national advocacy groups have been founded which promote BIM in Canada: the Canadian BIM Council (CanBIM) and the Institute for BIM in Canada (IBC) of which the Canadian chapter of buildingSMART International is a council. Both these groups have put forth considerable effort to engage the industry in moving BIM forward. While these organizations are gaining traction, they largely rely on individual effort to push the Canadian BIM agenda. At the provincial level, several "grass roots" organizations or committees have emerged in recent years. These could include Alberta Center for Excellence and aceBIM chapter, the BIM BC user group, as well as BIM Quebec group. These groups work in silo, and are not integrated. Again, the presence of an organization that is backed by all professional associations and is supported and funded by all levels of government can act as a unifying front to push a coherent Canadian mandate.

4.6 Reporting and Promotion of BIM

The reporting and promoting of BIM and innovative project delivery approaches is a very important component in driving widespread adoption and implementation. Experience has shown that there is a lack of distinction between promotion of these approaches by vendors and AECO organizations serving marketing purposes and objective reporting by independent bodies. Many claims have been made that are unsubstantiated and as such creates some scepticism in the industry. As such, an independent reporting of lessons learned and outcomes is needed to foster industry wide acceptance. In many countries, this responsibility is taken on by the organizations mandated to drive the initiative such as the BCA in Singapore and the BIM Task group in the UK. Both these organizations work on developing and monitoring activities such as forums, presentations, training, workshops, etc. The BIMForum in US also represents an important resource to address multidisciplinary practice and to keep industry up to date regarding advances in BIM.

In Canada, there are several activities that promote BIM, such as trade shows, conferences and symposiums. At the national level, bSC, IBC and CanBIM promote innovative approaches through conferences and workshops. At the provincial level, some private organisations are working on promoting new technologies and approaches such as Contech in Québec. Some professionals associations are beginning to be more involved in promoting BIM through conferences and workshops by inviting researchers and pioneer adopters to exchange their experiences and practices. Although the main goal is promoting BIM, the majority of these activities do not go beyond being purely informative in purpose. At the project level, as mentioned above, most of the promotion is led by firms who have worked on innovative projects and who use these cases for marketing purposes. In light of this, a centralized resource, which supports the objective capturing of lessons learned and outcomes for the Canadian AECO industry is needed. This resource should be maintained by the organization mandated with leading the national initiative.

4.7 BIM Research Programs

Lastly, the importance of research and development in this field is vast. The countries, which have succeeded in leading the reform of their AECO industries, all have invested in research programs to develop internal competencies and develop tools and technologies to support the transition. For example, Finland is famous for its research initiatives, innovation programs and establishments of international networks. The earliest research on BIM was initiated in the 1980s. Just after the recession in the early 1990's, 'the Finnish technology policy and industry leaders agreed about the need to develop the cluster [focussing on the AECO industry] and identified some key problem areas in the industry' with a focus on

'information sharing and management in all processes during an asset's lifecycle (Kiviniemi, 2006). This led to the emergence of TEKES's technology programs and later on, in 1994, to emergence of International Alliance for Interoperability (IAI) with the focus on the development of IFC data specification internally and since 1996 at the international scale. This was followed by developments such as VERA (1997-2002) and SARA (2003-2007) (Froese, 2002, Kiviniemi, 2006). The outcomes of these programs were first BIM guidelines in 2007 in Finland. More recently the PRE project, led by RYM OY has received important funding from both the government and industry. The US also has heavily invested in R&D. For example, the National Institute of Building Science (NIBS) and the National Institute of Standards and Technology (NIST) are the two main organizations, which carry out research on BIM. Whereas NIST is a governmental agency, NIBS is a Not-for-profit, which regroups representatives from the government, industry and academia. The American chapter of buildingSMART is integrated within NIBS. NIBS oversees the development of open data exchange standards such as IFC and COBie as well as the National BIM Standards. There are other organisms that conduct research in the AECO industry in the US such as Fiatech and the Construction industry Institute (CII).

In Canada, many research groups; universities and organizations are involved in the study of BIM and integrated approaches. Research groups, such as the BIM Topics lab at the University of British Columbia; research groups at the University of Calgary, the University of Alberta, the University of Ottawa and University of Waterloo, Concordia University and the GRIDD at the École de Technologie Supérieure, work with the industry through pilot projects to develop better practices for BIM and other construction innovations based on industry needs. The Canadian government has some programs to fund these researches and to create bridges between industry and academia and research centers such as Engage Grants or Industrial Research Assistance Program (IRAP). These programs allow industry to have access and to exchange knowledge with researchers. However, many of these research projects are one off and remain fragmented and the findings are highly contextual. Another key issue that must be addressed is related to adapting educational program to current realities. According to Forgues and Farah (2013), Canada needs to swiftly update and reform its university curricula to reflect the innovation and integration. There is a need to redefine professional curricula to fit the new context of integrated approaches. Certification of these new programs must be standardized and governed by a certifying body, as is the case with other programs that lead to professional accreditation.

5 CONCLUSION

This article has outlined the various initiatives from around the world that are driving the reform of the AECO industry. Innovative approaches to project delivery and asset management, such as BIM, IPD, IDP and Lean construction, are increasingly being relied upon to improve the performance and value generated by an industry that has long been seen as inefficient and wasteful. Many countries consider that their respective AECO industries contribute significantly to the development of their society, economy and have a very big impact on their environment. By acting as a driving force, and by providing the impetus to the industry to transform itself, governments around the world are tooling their AECO industries to become better and to remain competitive in light of increased global pressures such as global competition, move towards sustainability and carbon neutrality and increasing economic pressures on governments to deliver projects on-time and on-budget

In this regard, Canada cannot afford to remain idle. Active steps must be taken to follow suit to these other countries. This paper has discussed six attributes to successfully drive the adoption and implementation of BIM at a national scale. While the context in which the Canadian AECO industry operated is unique, there exists some mechanisms and strategies which can structure and adapt the adoption process to this particular context. Learning from abroad, a Canadian mandate can rely on international efforts to inform its initiatives, namely by adopting Open standards and developing guidelines that are inspired by best practices from elsewhere. More importantly, the Canadian initiative must share a single vision. It will need the backing from constituent organizations and professional associations across Canada as well as being endorsed by all levels of government.

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