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BIM Innovation Capability Programme: an Irish BIM Study

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Global BIM Study

Lessons for Ireland's BIM Programme

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Pictured from left to right:
Dr. Barry McAuley
Dr. Alan Hore
Professor Roger West



CITA: BIM Innovation
Capability Programme



Executive Summary

Below:
The Bank of China Tower

Right:
The Kingdom Tower of Riyadh city in Saudi Arabia

Bottom:
The eighth Bahá'í temple in Santiago Region



Executive Summary

The Construction IT Alliance (CITA) has been promoting the benefits of digitisation in the construction and engineering industry in Ireland since its formation back in 2002. Whilst the Alliance has always strived to ensure that its members are exposed to a wide spectrum of contemporary digital tools and processes, the concept of Building Information Modelling (BIM) has dominated the focus of its activities over the past five years.

CITA would like to acknowledge the importance of the support provided by Enterprise Ireland for BIM Initiatives in recent years. These initiatives include supporting companies through the use of Innovation Vouchers, leveraging funding from the BIM-Enable and BIM-Implement programmes and the most recent initiatives of the BIM Innovation Capability Programme and the launch of Ireland's National BIM Council. This has fostered momentum in respect to the interest among architectural, engineering and construction (AEC) businesses to embrace innovation technologies and processes such as those offered by BIM.

An explicit ingredient of the BICP involves conducting a comprehensive literature review of global BIM adoption initiatives, with a particular focus on successful enablers in international regions. This report seeks to carry out the first phase of this work by examining at a relatively high level, the adoption of BIM in particular international regions where BIM is currently a requirement or is likely to be a requirement in the near future.

Whilst there are a suite of noteworthy publications referenced in this report, a more comprehensive review is not scheduled to be completed until September 2017. The ultimate aim of the study is to investigate the "state of the art" and to gauge the maturity of BIM adoption internationally.

The world of BIM is a complex one and coupled with a requirement to carry out a comprehensive literature review it is a challenging prospect to capture accurately the status of BIM across the world at this time. What is evident within this report is the significant adoption of BIM by Governments throughout the world

Whilst globally respected publications like the McGraw Hill Construction SmartMarket Report in 2014 *The Business Value of BIM for Construction in Global Markets* (McGraw Hill, 2014a) and the *NBS International BIM Report* in 2016 (NBS, 2016) are specifically referred to, this report will mainly focus on evidence of regulated BIM, key champions and noteworthy publications within each of the chosen countries.

The key output of this report is to learn from our international colleagues as Ireland progresses with the development of its national BIM programme in 2017.

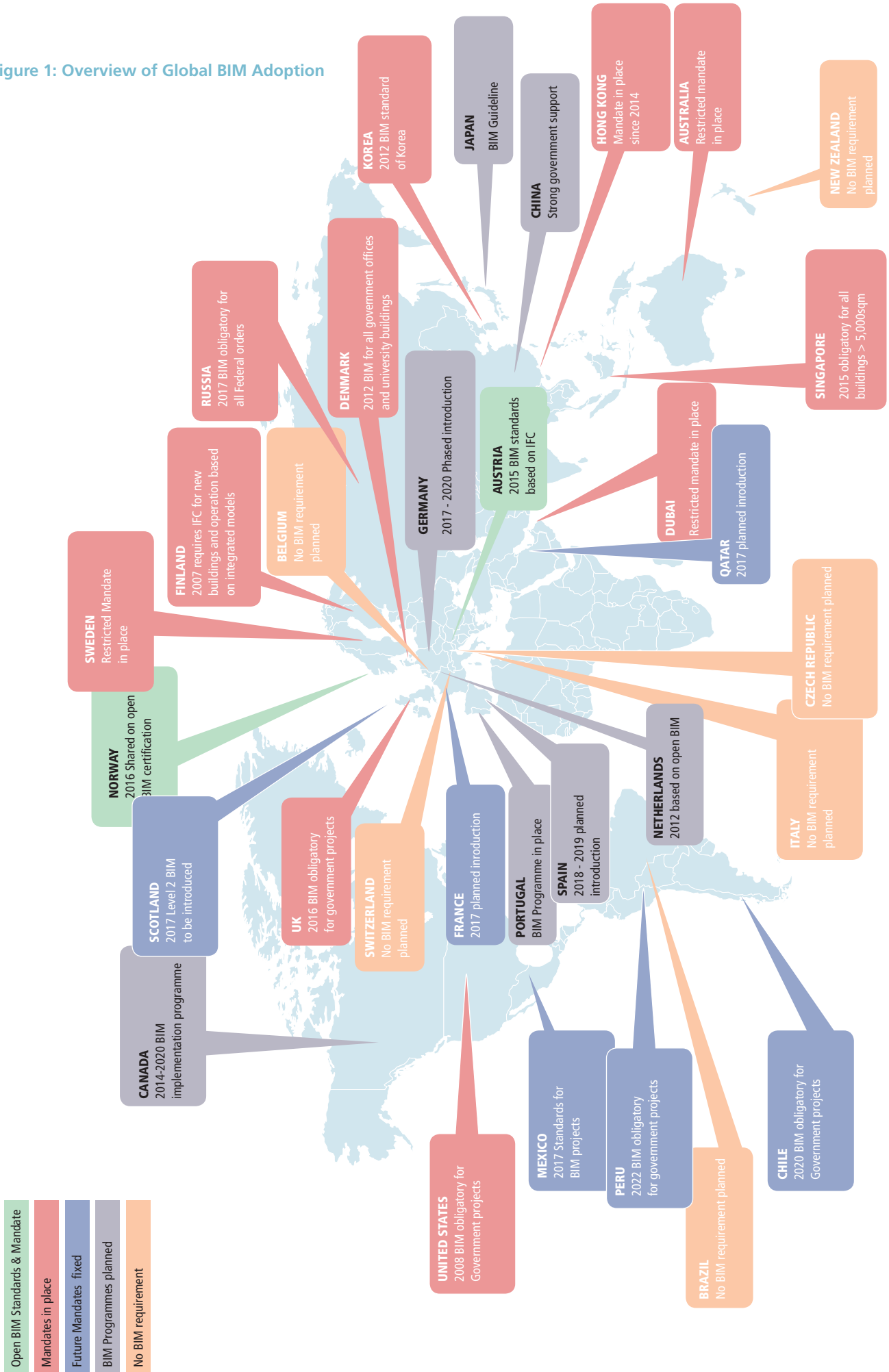
Dr. Alan V Hore,
Principal Investigator, BICP

"BIM and its innovation agenda is probably one of the most important catalysts for construction industry reform and modernisation we have seen globally in the last century."

David Philp
AECOM
Chair of the Scottish BIM
Delivery Group
CIOB Ambassador



Figure 1: Overview of Global BIM Adoption



A compelling case for BIM adoption across the globe

One thing that is for certain is that BIM is preoccupying the world of construction and engineering business. The recent World Economic Forum report *Shaping the Future of Construction* (WEF, 2016) reported that most other industries have undergone tremendous changes over the last few decades, and have reaped the benefits of process and product innovations. Furthermore the WEF reported that the construction sector has been hesitant about fully embracing the latest technological opportunities.

The WEF report outlined how labour productivity in construction has largely stagnated with only the fishing industry investing less in innovative Research and Development (R&D). The forum acknowledges that this is beginning to change thanks to digitalization, innovative technologies and new construction techniques such as BIM, Augmented Reality (AR), drones, 3D scanning and printing, all now reaching market maturity.

A core technology at the forefront of this transformational change is BIM. The recently published report by Daedal Research, *Global BIM Market: Size, Trends and Forecasts (2016-2020)* reported that the global BIM market is expected to reach almost \$8 billion by 2020, at a compound annual growth rate of 13% between 2015 and 2020 (Daedal Research, 2016).

The implementation of BIM in the construction industry is accelerating globally. Back in 2014 McGraw Hill reported that contractors were using BIM globally on over 30% of their projects (McGraw Hill, 2014a). More recently, a survey by National Building Specification (NBS) in the UK (2016) reported that BIM usage in the UK increased from 13% in 2011 to 54% in 2016 amongst all construction professions. While it is recognised that implementation is increasing across many countries, the level of BIM use and the rate it is increasing varies between the different regions.

Governments across the globe are increasingly recognising the efficiencies that can be gained with this change. Learning from leading jurisdictions, governments which are embarking on the transformational journey have been convinced that the strategic use of BIM can support a leaner more innovative construction sector thus addressing declining productivity prevalent in construction (Kelly et al, 2013 and Farmer, 2016).

An overview of Global BIM adoption is illustrated in Figure 1, demonstrating that there is considerable uptake of BIM by governments across the globe. The General Services Administration (GSA) is the pioneer in implementing BIM in the US on public sector projects.

Currently the governments of the UK, Hong Kong and South Korea have taken an aggressive stance with BIM initiatives in recent years, as have the Scandinavian countries of Norway, Denmark and Finland who have been working with BIM for over a decade now.

It is clear from this momentum that Ireland needs to embrace BIM and be seen to do so by its international trading partners to prepare Irish construction and engineering businesses to work in regions where BIM is a requirement and also to prepare for the increased requirement for BIM at home by industry and government.

“The future of construction requires the commitment and encouragement of many active participants in our industry – people who believe in a modern E&C industry that will benefit all”.

John M. Beck, (WEF, 16)

buildingSMART

A particular feature of many international BIM programmes is the involvement of buildingSMART Alliance. The goal of the organisation is to improve cost, value and environmental performance of buildings through the use of open sharable asset information. BuildingSMART has been at the forefront of implementing BIM by developing and maintaining the Industry Foundation Class (IFC) platform, which makes it possible for interoperability between different native CAD software.

Presently there are eighteen buildingSMART chapters globally, many of which are referred to in the profiles of the countries presented.

Chapters include Spain, Canada, Australasia, Benelux (Netherlands, Belgium, Luxembourg), France, Germany, UK and Ireland, China, Italy, Japan, Korea, Malaysia, Nordic (Denmark, Finland Sweden), Norway, Singapore, Switzerland and the United States.

Recently buildingSMART (Australasia) published an industry recommendation report entitled *Meeting Government Policy Objectives through the adoption of Building Information Modelling (BIM)* (buildingSMART, 2016).

In recent years governments at all levels across Australia, have committed to significant policy targets regarding public construction, emissions reduction, procurement transparency and value for money public assets. Yet achieving these targets remains a vexing problem for most jurisdictions because of the lack of adoption of transformative technologies that would enable such targets to be met. In some jurisdictions the disconnect between the policy targets and the mechanisms to achieve them are great, making them difficult to achieve. However things do not have to be this way.

Meeting Government Policy Objectives through the adoption of Building Information Modelling (BIM) (buildingSMART, 2016).

Global BIM Maturity

Dr. Bilal Succar (Change Agents AEC, Australia) and Dr. Mohamad Kassem (Northumbria University, United Kingdom) have carried some important and early work in global BIM adoption. One of their models, the Macro Maturity Components Model, identifies eight complementary elements (See Figure 2) for measuring the BIM maturity of countries and assisting policy makers to develop BIM adoption policies.

The eight components are: Objectives; Stages & Milestones; Champions & Drivers; Regulatory Framework; Noteworthy Publications; Learning & Education; Measurements & Benchmark; Standardised parts & Deliverables; Technology Infrastructure. The model can be used holistically using a comparative matrix, or granularly using component-specific metrics. This and other models, the macro adoption metrics and the macro maturity matrix, are presented in their recent journal paper entitled "Macro-BIM adoption: Conceptual structures" (Succar and Kassem, 2015).

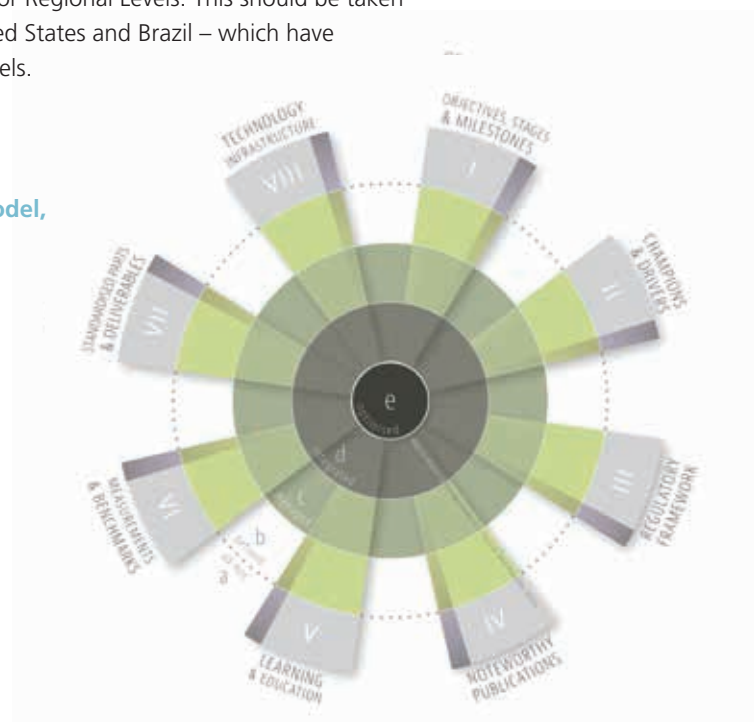
The Macro Maturity Components model was lately used as part of an international BIM adoption survey covering 21 countries: Australia, Brazil, Canada, China, Finland, Hong Kong, Ireland, Italy, Malaysia, Mexico, Netherlands, New Zealand, Portugal, Qatar, Russia, South Korea, Spain, Switzerland, United Arab Emirates, United Kingdom, and United States.

The results from the international survey included many important findings – for example:

- No country has achieved the highest rating across all eight components.
- The UK achieved the highest maturity in the largest number of components (four out of eight): Objectives, Stages & Milestones; Champions & Drivers; Regulatory Framework; and Noteworthy Publications.
- Learning & Education in Ireland was rated higher than all other countries;
- The Technology and Infrastructure score was highest in South Korea, and Standardised Parts and Deliverables was highest in China;
- The UK displayed the highest cumulative maturity (sum of maturity score across all eight components) followed by China, South Korea, Finland, the Netherland, Spain, and the United States, however, the UK's highest cumulative rating of 17.7 pts is still relatively low when compared to the highest possible score of 32 points (4 points per Component).
- All countries have gaps (null score) in their macro BIM maturity. For example, Canada has gaps in four macro maturity components; Switzerland has gaps in five macro maturity components; Russia has gaps in three macro maturity components; etc.,
- Most ratings of macro maturity components across the 21 surveyed countries (156 ratings out of 168 ratings – 8 ratings by country) are equal or below 50%. This indicates a generalised medium-low maturity worldwide across most components.

It is worth noting that this study treated each country as a single unit. That is to say there was no assessment of the differences in maturity at State or Regional Levels. This should be taken into consideration for countries - such as the United States and Brazil – which have institutions operating at both federal and state levels.

Figure 2: The Macro-Maturity Component Model,
(Succar and Kassem, 2015)



How are we doing?

In the most recent survey carried out by Enterprise Ireland in association with CitA, in excess of 80% of the 100 organisations surveyed reported an increased demand for BIM from their clients (Enterprise Ireland and CitA, 2016). 57% of the sample reported that their awareness of BIM had improved significantly and were now using BIM on a number of projects. A further 33% reported that their awareness had slightly improved and they were using BIM on some of their projects. Only 4% of the sample from last year claimed that their awareness had not changed. It also found that 66% of the sample believe that Ireland should follow in the footsteps of the UK and mandate BIM. This is in comparison to the 50/50 breakdown in 2015.

Whilst there is evidence of an increasing level of collaboration amongst industry professionals in Ireland in recent years, BIM use remains very immature generally, in particular, among the SME business community.

While BIM is moving from the research paradigm into a commercial reality, the construction industry continues to lag behind others, such as, the automobile and manufacturing industries in its development of intelligent 3D models (Boon, 2009; Wong & Yang, 2010). BIM has been identified as a technology which has the potential to transform the current work practices in construction to make them more efficient, enhance the design of buildings and enable more efficient construction (Boon, 2009).

What follows is a general overview of the status of BIM in a total of twenty seven countries. In carrying out this initial scoping study researchers focused on three key ingredients;

1. The presence of any regulation or authorisation to mandate the use of BIM on public sector projects.
2. The existence of key champions that promotes BIM publicly on behalf of industry. This could also include a buildingSMART chapter, government agency, task groups, etc.
3. The publication of any noteworthy documents prepared or commissioned by international governments that would be of assistance to Ireland in the formulation of its BIM programme.

“The use of BIM is the backbone of a leaner, digitised built environment. The ability that BIM provides to design, construct and operate a building virtually is an important tool to increase productivity while at the same time improve the quality of work. But what’s becoming clearer is that digital working alone is not the only benefit of BIM. Being able to better manage and share data is improving collaboration across the design and construction phases, as well as seeing money and time savings and a reduction in disputes.”.

Chris Blythe,
Chief Executive, CIOB

Europe

Many countries across Europe have shown a particular enthusiasm for BIM in recent years following the 2013 EU Procurement Directive which showed its support for BIM through its ratification by the European Parliament. There is at present a rapidly evolving suite of national digital programmes across the EU.

Table 1 provides an overview of the rapidly evolving digital programmes across Europe presently and the key drivers in those countries

Table 1 - Rapidly Evolving National Digital Programmes

Germany	Planen bauen 4.0 (Digital Plan, Efficient Building, Sustainable Operation Initiative)	Norway	STATSBYGG (Directorate of Public Construction and Property)
France	Plan Transition Numérique dans le Bâtiment (Plan Digital Transition in Building)	Spain	Comisión para la implantación de la metodología BIM (Commission for the implementation of the BIM methodology)
Finland	Sennatti (Senate Properties)		
Netherlands	Rijkswaterstaat (Ministry for Infrastructure and the Environment)	UK	UK BIM Task Group
		Denmark	Bygningsstyrelsen (Property Agency)

The Scandinavian countries of Finland, Norway and Denmark as well as the Netherlands have been embracing BIM for almost a decade. More recent highly influential programmes are evident in the UK, closely followed by rapidly evolving programmes in France, Germany and Spain.

In 2016, a first milestone for BIM in European standardization was reached with the adoption of the first three European Standards. This was a result of the work by the European Committee (CEN/TC 442) who were set up in 2015 to develop a structured set of BIM standards. CEN/TC 442 have developed three international standards:

- EN ISO 16739:2016 - Industry Foundation Classes (IFC) for data sharing in the construction and facility management industries.
- EN ISO 29481-2:2016 - Building information models - Information delivery manual - Part 2: Interaction framework.
- EN ISO 12006-3:2016 - Building construction - Organization of information about construction works - Part 3: Framework for object-oriented information.

Now with the European Commission recommending the use of BIM in tender calls and the award of public construction contracts, the concentration of BIM regional programmes has become prevalent across the EU. This is likely to lead many EU nations to adopt BIM mandates or incentives including Ireland.

In 2015, the European Commission awarded the EU BIM Task Group the role of delivering a common European Network approach to align the use of BIM by public procurers, policy makers and public estate owners. The Task Group's vision is to encourage the common use of BIM, with the aim of improving value for public money, quality of the public estate and for the sustainable competitiveness of the EU construction sector.

It is stressed on the EU BIM Task Group website that the group will not be creating new or competing standards to ISO, CEN or buildingSMART but simply developing common guidance and practice for public procurers when introducing BIM.

The focus of the task group is the production of a handbook containing BIM guidance for public procurers and policy makers. It is intended that the handbook will include procurement measures, technical considerations, cultural and skills development and overall benefits for public procurers in the use of BIM. The group is currently co-ordinated by the UK Government's Department of Business, Innovation and Skills (BIS) and currently has fourteen European member states. These include representatives of public procurers, public building and infrastructure owners and policy makers from Denmark, Estonia, Finland, France, Germany, Iceland, Ireland, Italy, Spain, Sweden, Netherlands, Norway, Portugal and the UK.

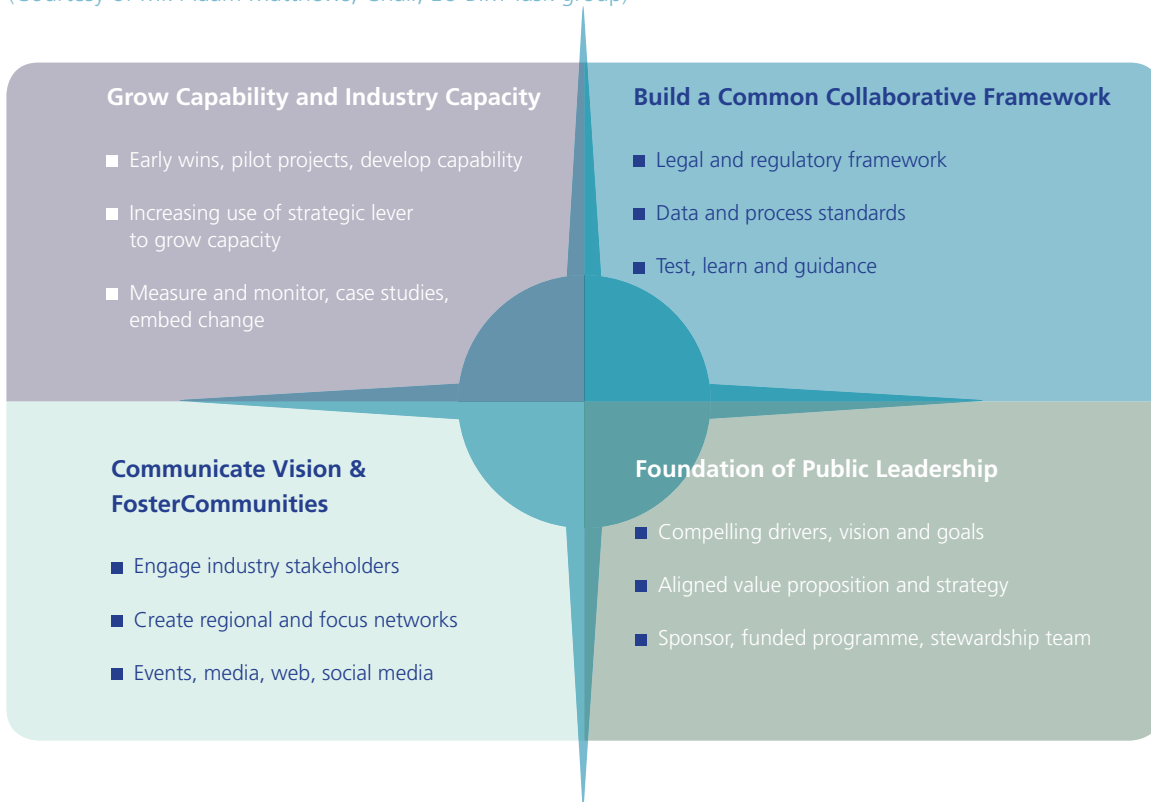
An overview of the Strategic Framework for Public Sector BIM Programmes developed by the EU BIM Task Group is illustrated in Figure 3.

As a group we believe that the public sector can show leadership across the union and ultimately help Europe develop a world-class digital construction sector – one that is open, digital and competitive

**EU BIM Task Group,
Adam Matthews**

Figure 3 - Strategic Framework for Public Sector BIM Programmes

(Courtesy of Mr. Adam Matthews, Chair, EU BIM Task group)

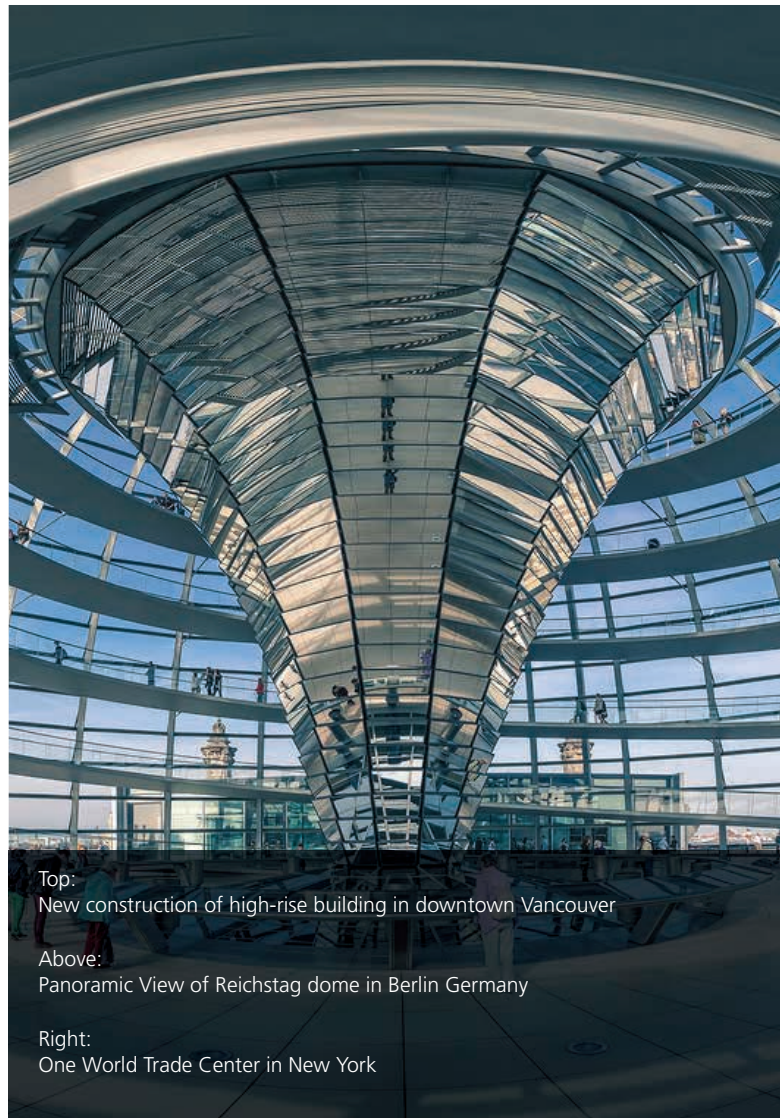




CitA: BIM Innovation
Capability Programme



CitA Global BIM Study: Country by country

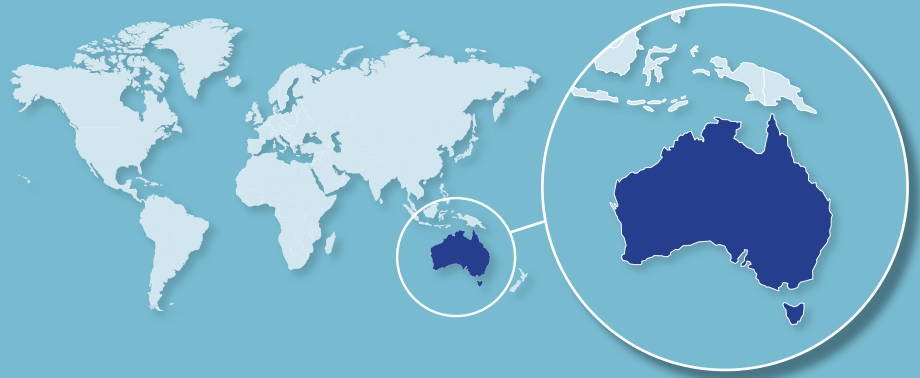


Top:
New construction of high-rise building in downtown Vancouver

Above:
Panoramic View of Reichstag dome in Berlin Germany

Right:
One World Trade Center in New York

Australia



The McGraw Hill Smart Market report 2014 reported that 61% of design professionals in Australia had implemented BIM to a high or very high level, with a predicted rise to 77% by 2016 (McGraw Hill, 2014b).

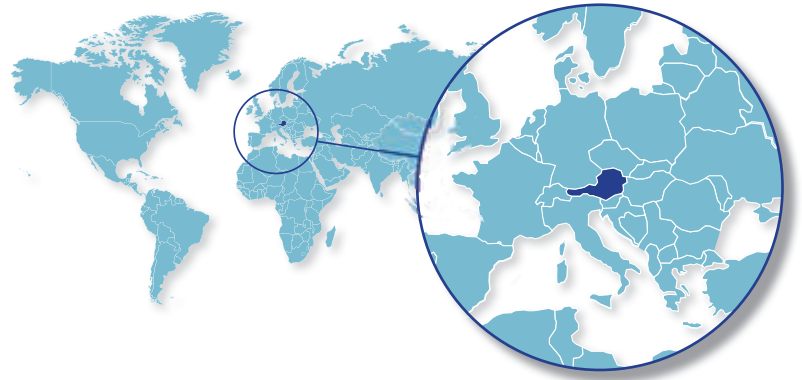
Smith (2014) reported that adoption has been intensifying in recent years which is in line with the McGraw Hill report. The acceleration was likely attributed to the *National BIM Initiative (NBI) Report* (buildingSMART, 2012b). The NBI report comprises of 2 volumes; *Volume 1: Strategy (what needs to be done)* and *Volume 2: Implementation Plan (how it should be done, with detailed costings and timeframes included)*. The *NATSPEC National BIM Guide and BIM Management Plan* has also been well received and is increasingly being adopted across the industry, both as a framework for building projects, as well as within education programmes (NATSPEC, 2011). It recommended that industry and the Australian Government work together to promote initiatives that will accelerate the adoption of BIM in Australia and ensure the growth of the construction sector. Smith (2014) credits buildingSMART by playing a leading role in BIM development and implementation in Australia by establishing an “Open BIM Alliance of Australia” that involved an alliance with a number of software vendors to promote the concept of “Open BIM”.

Regulation	New South Wales’ Health and the Australian Department of Defence have mandated BIM deliverables on larger projects
Key Champions	NATSPEC buildingSMART (Australasia)
Noteworthy Publications	National BIM Initiative Report (buildingSMART, 2012b) NATSPEC National BIM Guide (2011)

The Department of Planning, Transport and Infrastructure (DPTI) have developed BIM guidelines for government agencies, consultants and contractors, with the New South Wales’ Health mandating BIM deliverables on all projects over \$30 million. The Department of Defence recognises BIM benefits and plans to integrate BIM and IPD into its projects in the near future.

Universities have shown the greatest uptake of BIM in their undergraduate curricula, however, this has mostly been at a very basic level of information, simply covering the concepts of BIM or the basics of using a particular BIM software package. NATSPEC has been providing an introduction to BIM to undergraduate students at universities across Australia for a number of years. Curtin University has recently collaborated with Huazhong University of Science and Technology (HUST), Wuhan, China, to establish the Australian Joint Research Centre for BIM.

Austria



While there does not appear to be any formal BIM strategy adopted by the Austrian authorities, presently the main catalyst for BIM momentum is the Austrian Standards Institute, a non-profit service organisation. The current available standards were published in July 2015.

The subject of BIM is assigned to Working Group 011.09 of the Austrian Standards Committee 001 "Building Construction". The current standards are grouped into two publications, namely:

1. ÖNORM A 6241-1 – Digital structure documentation –
Part 1: CAD data structures and building information modelling – Level 2.
2. ÖNORM A 6241-2 – Digital structure documentation –
Part 2: Building Information Modelling (BIM) – Level 3 iBIM.

Austrian Standards offers all users a free file conforming with the standard (in German) for creating the data model

Regulation	Likely to be in place by 2018
Key Champions	Austrian Standards Committee
Noteworthy Publications	ÖNORM A 6241-1 (2015) ÖNORM A 6241-2 (2015)

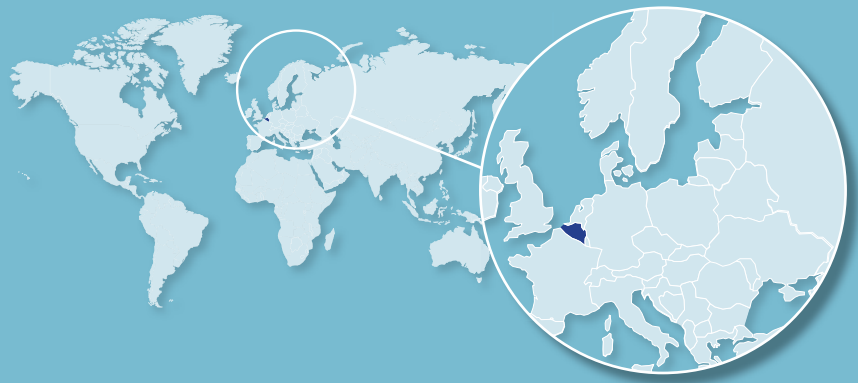
"If BIM becomes mandatory for public call for tenders after the next revision of the Directive on public work contracts planned for 2016, this has to be transposed into national law within two years. This means that BIM will be a mandatory technology for orders placed by public authorities from 2018 on".

Peter Kompolschek,
Chair Competent Committee at Austrian Standards, July 2015

"There is no document comparable to the Austrian BIM standard existed at the international level to date. ÖNORM A 6241-2 sets a standard that takes much more into account than other specifications on this topic,. When you can tell architects that the time required for obtaining permits is halved if they use BIM for planning, then it will be absolutely clear for them that they can do so"

Christoph Eichler,
BEHF - Corporate Architects

Belgium



The Belgian Building Research Institute (BBRI) is the main focal point on the digital revolution that BIM is playing in affecting the design, creation and the exploitation of future buildings in Belgium. The BBRI have been critical recently with the lack of national standards in Belgium and also reported that the industry was failing to utilise BIM to its full potential. The BBRI are currently seeking to familiarise construction professionals with the BIM technology and encourage its use in practice through general information sessions and workshops.

Regulation	No regulation to-date
Key Champions	The Belgian Building Research Institute Association of Major Belgian Contractors buildingSMART (Benelux)
Noteworthy Publications	Belgium Guide to Building Information Modelling (Colophone, 2015)

Boeykens., et al (2013) explored the position of BIM within Belgium at the time as slowly gaining more attention, amongst professionals and educators, where it is sometimes regarded as merely a software tool or an alternative method to 3D modelling. The authors concluded that the potential productivity gains that are promised by BIM use were not at that time experienced in Belgium.

Despite the lack of BIM adoption in Belgium, working groups, such as, the ADEB-VBA's (Association of Major Belgian Contractors) BIM work group have made significant efforts to promote its use with the production of a Guide to Building Information Modelling (Colophon, 2015). This document provides guidelines and practical rules improving collaboration and management of traditional DESIGN-BID-BUILD contracts using digital documents/exchanges. The ADEB-VBA's BIM working group focused on the Design-Tender-Build form of contract and defined practical guidelines related to digital exchanges within this context.

"The number of challenges will certainly not decrease in the future, with notably the digital revolution that will affect the design, the creation and the exploitation of future buildings. The application of BIM (Building Information Model) will undoubtedly play a central role in this revolution"

Belgian Building Research Institute, Annual Report 2015

Brazil



Brazil's National Department of Transport Infrastructure is embracing BIM in the hope of it assisting in achieving a 30% cost saving across the building lifecycle. Despite the fact that Brazil has no official government standard, the use of BIM is quickly rising for Brazilian building and infrastructure projects (CIOB, 2015).

In the McGraw Hill (2014a) it was revealed that BIM use was increasing among contractors in Brazil at a higher rate than any of the other markets examined. AEC firms have been leading the way in developing internal BIM workflows and processes to keep pace with foreign competitors.

Regulation	Roadmap under review / consideration
Key Champions	BIM Interdisciplinary Group BIM Brazil Network
Noteworthy Publications	A Roadmap for BIM Adoption in Brazil (Kassem, 2015)

The Brazilian AEC sector has only recently started BIM implementation, and the companies which have invested in this initiative in the past few years belong mainly to the private sector (Souza et al. 2013). The authors discuss how a number of Brazilian institutions have been developing study and work groups aiming to debate the implementation of BIM, and to promote its concept within the construction community by promoting events and courses. The concept of BIM is still, however, not widespread in the Brazilian market.

Souza et al. (2013) describes that interest groups include a BIM Interdisciplinary Group which is a regular discussion group that was created on the initiative of AEC associations. Also a BIM Brazil Network funded by the Brazilian Federal Agency for the Coordination for the Improvement of Higher Education Personnel is responsible for several initiatives, such as BIM workshops and courses, promotion and sponsoring of BIM congresses, and contributing to the development of BIM national practices. A BIM Standard Committee has recently created the first BIM standard in Brazil (NBR 15965-1 – Construction Information Classification System).

On assignment from the Ministério do Desenvolvimento, Indústria e Comércio Exterior and the Ministério do Planejamento, Orçamento e Gestão, under the sponsorship of the European Union Programme - Brazil Sector Dialogues, Dr. Mohamad Kassem and Prof. Sergio Leusin conducted a structured examination of BIM in the EU and in Brazil (Kassem et al, 2015). The report is available in English.

Canada



A number of public organisations in Canada have implemented openBIM standards in their overall strategy, namely the Department of National Defence (DND) Québec and the Ministry of Infrastructure in Alberta (RIBA, 2016).

The Institute for BIM in Canada (IBC) is leading and facilitating the coordinated use of BIM in the design, construction and management of the Canadian built environment. The program delivery arm of the Institute for IBC, have created a *Canadian Roadmap for Lifecycle BIM* in the Canadian AECO community. The roadmap calls to action to engage the Architecture Engineering Consultancy/Facilities Management (AECFM) community, foster consensus, and move towards open BIM-based collaborative project delivery and building lifecycle processes. It is a living document with the outcomes of a National BIM mandate setting out the framework (technological, organizational and procedural) for the deployment of collaborative BIM-based project delivery environments in the Canadian AECFM community. Broadly the Roadmap contains six pillars, namely: Engage, develop, educate, deploy, evaluate and sustain.

Regulation	No regulation to-date
Key Champions	Canada BIM Council (CanBIM) Institute for BIM in Canada (IBC) buildingSMART (Canada)
Noteworthy Publications	AEC(CAN) BIM Protocol (AEC-CAN, 2014) Canadian BIM Practice Manual (CanBIM, 2015)

The Canadian BIM Council (CanBIM), who are the business voice of Canada's BIM Community initiated discussions in 2011 with the UK BIM Task Group to develop a parallel protocol. This protocol details how CanBIM believes that the AEC BIM community in Canada is better served by taking already existing, working standards and investing time in collaboration to make the current standard better, rather than simply reinventing and creating a unique standard for Canada.

A buildingSMART Canada Education Committee was established to coordinate and facilitate such activities to achieve BIM education.

Government funding has been secured under the Industrial Research Assistance Program (IRAP), within the National Research Council of Canada, for the IBC to deliver a Canadian Practice Manual for BIM.

Chile



The Chilean government believe the introduction of advanced digital models that allow the integration of project management at different levels and stages will help achieve sustainability targets. This plan is heavily influenced by the UK and is coordinated by the National Economic Development Agency (Corfo) through the Strategy Programme for Productivity. The BIM Plan seeks to achieve the requirement of BIM for public projects by 2020, and tentatively the requirement of BIM for private projects by 2025.

The main goals of the plan are a 20% reduction of project costs and a 20% reduction of projects design and construction time. A road map will be developed from an existing preliminary road map which was developed through public private forums. A key driver for BIM was to tackle the problem of significant cost overruns. The aim is that a BIM mandate will help reduce project costs and overruns by having more detailed planning and coordination prior to construction.

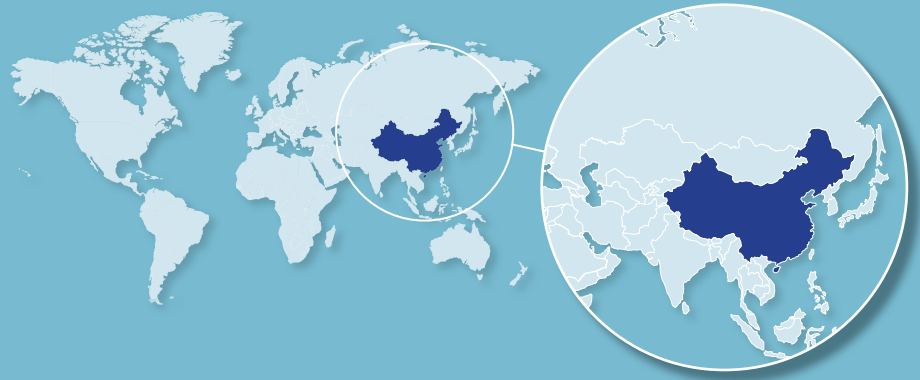
Regulation	BIM Mandated for 2020
Key Champions	BIM Forum Chile National Economic Development Agency (Corfo)
Noteworthy Publications	Chilean 10 year BIM Plan (Soto et al, 2015)

“In January of 2016 the Ministries of Finance, Economy, Public Works, Housing and Urban Development and the Chilean Chamber of Construction and Construction Institute signed an agreement pledging to support the BIM Plan and necessary actions for the implementation of BIM in Chile. The main objective of the plan is to develop a public private process to modernise the construction industry, increase its sustainability, develop industrial capacity and create a dynamic that allows for greater productivity. ”

Carolina Soto, Executive Director of the Chilean BIM Plan

The BIM Forum Chile are the main technical reference and meeting point in Chile around BIM, generating projects, activities and standards that add value to businesses and professionals in the construction sector. To achieve this, a number of working groups have been created which are based around standardization and technology transfer that are linking with other national and international organisations in order to promote technology transfer. Other working groups include education and project management.

China



China's Ministry of Housing and Urban-Rural Development's 12th National Five-Year Plan declared that the key focus of their nation's building industry development will be industrialisation, informatisation, urbanisation and agricultural modernisation, with a key role for BIM technology in each area (Ji et al., 2014).

The China BIM Union has been approved as the China Industry Technology Innovation Strategic Alliance by the Ministry of Science and Technology of the People's Republic of China in 2013. The China BIM union have helped develop the Chinese National Standard "Unified Standard for BIM Application" along with a series of standards for P-BIM (Practice-based BIM) software applications and data exchange for specific tasks.

Regulation	BIM required through the 12th national Five-Year Plan
Key Champions	China BIM Union
Noteworthy Publications	McGraw Hill Construction (2015), The Business Value of BIM in China, SmartMarket Report, McGraw Hill Construction, Bedford MA, United States

Current BIM objectives for China include data sharing and interoperability across the project life cycle. The main motivation is to improve efficiency within the Chinese industry (NATSPEC, 2015).

The McGraw Hill smart market report on the business value of BIM in China described that the percentage of those using BIM was expected to grow within the next two years by approximately 90% among architects and 110% among contractors (McGraw Hill, 2015). The report detailed that the top business benefit reported by contractors included the use of BIM to enhance their organization's image as an industry leader. Structural barriers include difficulties with changing traditional methods, such as, Chinese law that requires the design and construction to be separated.

The recent Shanghai Disneyland Resort project had nearly 3,000 clashes identified over a six month period before the issuing of the tendering package, as a result of using BIM. The Beijing Water Cube, Canke Golden Mileage, the Tianjin Port, International Cruce Terminal and Shanghai Tower are all examples of other successful BIM case studies in China.

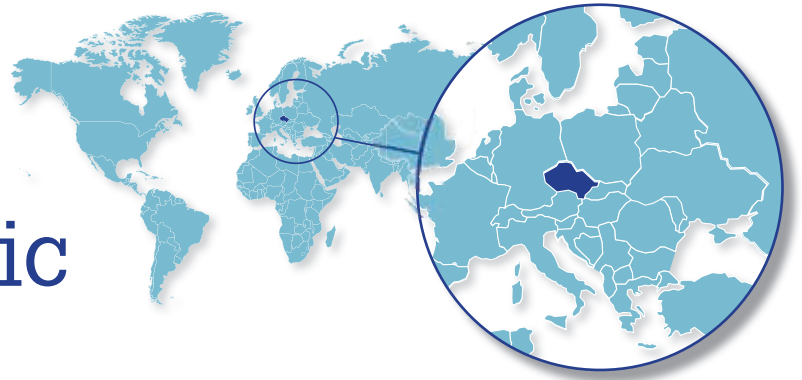
"We also need to create the sense of urgency by letting [the industry] know that BIM is an inevitable trend. Companies and individuals need to get a head start instead of waiting it out; otherwise, the adoption is not going to progress. For software vendors, they need to package and customize BIM with the local culture, which is very different from the western countries. Continuing to promote BIM as a software tool will create a huge ongoing problem".

Professor Gu Ming
Vice Dean of the School of Software
Tsinghua University

"BIM will be the future IT solution in China; The Chinese Government is strongly supporting BIM"

Tsinghua University,
Beijing

Czech Republic



Awareness of BIM in the Czech Republic is increasing due in part to the activities of the Czech BIM Council (NATSPEC, 2015). The Czech BIM Council is the first institution in the Czech Republic which aims to implement the BIM processes into the Czech building industry, design processes, education, standards and legislation. Some of their activities include a BIM DAY which has run since 2013 and the establishment of the Czech BIM Guide.

Other activities include the BIM Summer School which offers guidance and professional advice on how to successfully implement BIM. The Czech BIM Council has recently set up a working group titled 'BIM and Education' to encourage the greater use of BIM into the education system. In 2013, the Czech BIM Handbook was released which has provided a methodology for practicing BIM amongst the different professions.

Regulation	No regulation to-date
Key Champions	The Czech BIM Council Expert Council for BIM
Noteworthy Publications	Unknown

In late 2015, the Government Council recommended to the Czech Government to take measures aimed at the gradual introduction of BIM in the Czech Republic, with the aim of reducing operating and investment costs with emphasis on the application of public procurement.

Juszczuk et al., (2015) reported that the Czech Republic are just beginning to use BIM technologies and develop information modelling but mostly the 2D design documentation process is still preferred. The reason for this is the absence of standards and legislative regulations for BIM application and a disagreement about BIM implementation levels.

The most recent NBS International BIM Report stated that in the Czech Republic, almost half of the 157 respondents are aware of BIM, but only 13% use it (NBS, 2016). The price of BIM software is the biggest obstacle in BIM implementation for half of respondents (mainly small companies). The report also details that most of those who were aware of BIM (87%) believe that BIM is the future of the construction process.

Denmark



Denmark was an early adopter of BIM, with the implementation covering public construction projects first set out by regulation 1365 in 2007. The current ICT regulations 118 and 119 for projects exceeding DKK5m have been in effect since 2013.

Over the past nine years, the Danish government has set regulations, promoting the use of ICT technologies as a main measure against the stagnating productivity growth in the construction sector. Denmark is a particularly interesting case giving an insight into a trend-setting BIM initiative that has had some time to develop.

Regulation	Mandatory requirement since 2007 (extended adoption in 2011)
Key Champions	Molio (former BIPS and Byggecentrum) Bygningsstyrelsen (Danish Building and Property Agency) DiKon (Digital Convergence)
Noteworthy Publications	CCS Classification and Identification (Danish Construction Classification System 2015) 3D Working Method guideline (BIPS, 2008) CCS Levels of Information, CCS Purposes (2016)

Bolpagni (2013) acknowledges that these requirements are also in effect in public sector renovation projects since the 1st of January 2008 and for state supported social housing since the 1st of January 2009. Since June 2011, the Danish Parliament extended the mandatory adoption of BIM to all local and regional projects worth over €2.7 million, while central government projects had a lower threshold of €677,000.

One of the leading organisations Byggeri Informationsteknologi Produktivitet Samarbejde (BIPS) has been promoting BIM since 2003 with the aim to increase the effectiveness of the process of design and construction from the building programme to management and maintenance. Denmark buildingSMART has been part of BIPS since 2009. To support BIM adoption, BIPS published several standards to support the development of digital constructions, which include the Danish Building Classification System and 3D Working Method guideline.

As of June 2016 Byggecentrum and BIPS have merged under the new joint name of Molio. Molio is also taking over BIPS role as the buildingSMART network in Denmark and will coordinate buildingSMART activities. This network will be the focal point of Danish involvement in international buildingSMART development projects.

Digital Convergence (Dikon) is a collaboration between six of the leading operators in the Danish construction sector who are all working together to implement and disseminate common IT standards in the entire Danish AEC sector. A number of third level institutions, such as Aalborg University, Aarhus School of Architecture and the Technical University of Denmark's provide education within the area of interoperability and 3D Modelling.



Dubai

(United Arab Emirates)

In November 2013, the Dubai Municipality issued a circular mandating BIM for specified architecture and MEP works in the Emirates. The municipality’s regulations applied to buildings over 40-storeys tall or those which span more than 27,871m², as well as government projects, including hospitals, universities and schools.

In July 2015, an updated circular was issued which detailed Dubai Municipality’s intent to expand the usage of BIM for project owners, consulting firms, contractors and government departments. This updated mandate requested that BIM is to be used for architecture and MEP on buildings that are above 20 floors for all governmental projects. There is also a requirement for structural models for buildings of more than 40 floors.

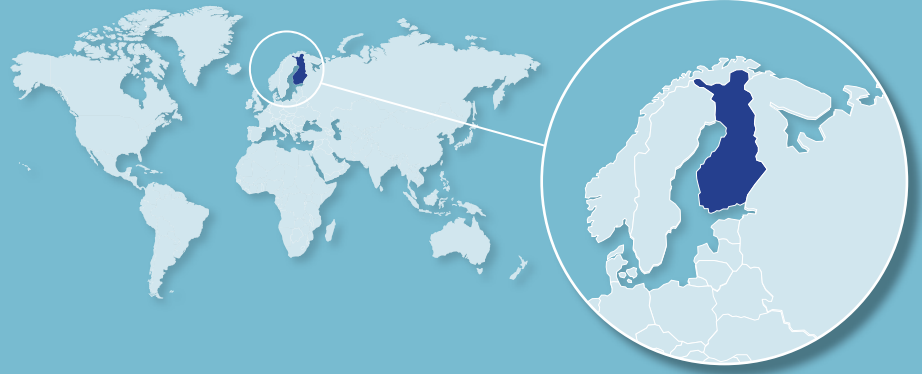
Regulation	BIM Mandated since 2013
Key Champions	Dubai Municipality Emirates BIM Group
Noteworthy Publications	Dubai Municipality 196 and 207 circular

Abdalla (2016) outlines that in order to promote this initiative the municipality has called on local construction companies to fully support and provide data to develop a national databank for research and development.

Mehran (2016) described that the main problem in implementing BIM in the UAE and Dubai included the absence of any published and accepted BIM standards and protocols. Mehran outlines that while most clients want to have BIM used in their projects, they do not have a clear understanding of its meaning and practical implication.

Current groups like the Emirates BIM Group have been formed to assist in introducing the software required for BIM to those who have just started out in their BIM journey. With the Dubai Metro expansion and World Expo 2020 in the pipeline, the emirates will be seeing a lot of major infrastructure developments in the foreseeable future.

Finland



Since 2001, Senate Properties has carried out several pilot projects to develop and study the use of product models (Wong et al., 2009). The Confederation of Finnish Construction Industries decided in 2002 that BIM would be a core element of the future direction of the Finnish construction industry (CIOB, 2015). More recently the City of Helsinki (The Real Estate Department), HUS (The Hospital District of Helsinki and Uusimaa), Senate Properties and City of Vantaa (The Real Estate Department) have produced a BIM project guideline for clients (Bolpagni, 2013).

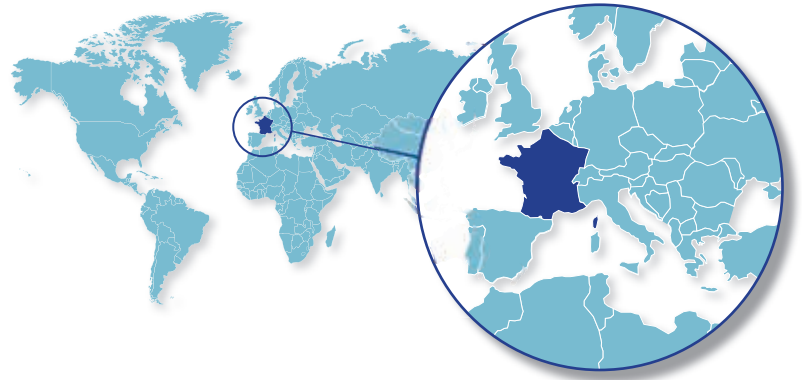
Regulation	Senate Properties (2007) Finish Transport Agency – Inframodel 3 (LandXML) (2014)
Key Champions	Confederation of Finnish Construction Industries buildingSMART (Finland) Senate Properties (Senaatti)
Noteworthy Publications	buildingSMART (InfraBIM requirements, 2015) buildingSMART (Common BIM Requirements, 2012a)

Within the private sector there are several major companies, such as, ‘Skanska Oy’ and ‘Tekes’ who have taken the lead in working with BIM (Kiviniemi, 2009). Research organisations and universities in Finland are running several programmes involving the implementation of BIM, such as Helsinki University of Technology and VTT’s Engineering and Construction Project Information Platform (ECPIP) (Wong et al., 2009).

Universities and polytechnics provide BIM education for their students. All current construction and architecture students study BIM to some extent. Large companies, such as, Skanska (construction) and Senaatti (state client office) arrange focussed in-house training (NATSPEC, 2015). buildingSMART Finland also disseminate information on BIM and support its member companies in implementing BIM-based processes.

The InfraBIM requirements (vol 1-7) were published in 2015 by buildingSMART Finland. The first volumes are now available in English. The resulting documents are used as general technical references and modelling guidelines during procurement and construction. The guidelines are accompanied by the Inframodel 3 data exchange format and the InfraBIM Classification System. The results of InfraBIM pilot projects are available online but are presently not available in English.

France



In France the gradual adoption of BIM began with the goal of 2017 when BIM is expected to streamline all public sector projects. The French Government is of the view that the greatest value for BIM is within the housing sector, where BIM will be deployed on 500,000 houses by 2017 (Mordue et al., 2016).

In 2014 the French construction stimulus plan was created to accelerate the deployment of digital tools throughout the entire building sector. The transition plan has received funding of €20m over three years. The French Government, in response to other European movements aims to mobilise and support the sector to embrace the digital revolution, by deploying operational actions that unite initiatives to capitalise on what exists and create the conditions for a shared benefit for the entire industry. This resulted in the establishment of the Le Plan Transition Numérique dans le Bâtiment (the digital transition building plan) task group who is responsible for the French Roadmap.

Regulation	Mandated for 2017
Key Champions	Le Plan Transition Numérique dans le Bâtiment buildingSMART (France)
Noteworthy Publications	Le Plan Transition Numérique dans le Bâtiment, (2015), Plan for the digital transition in the building industry, June 2015.

The French road map discusses plans for educational kits which will provide an understanding of the tools associated with BIM. There are also requests for an industry portal to highlight the main features and make it accessible to all: good practices, documents explaining concepts and strategies, stakeholder and software references, etc.

In response to the growing need for BIM training, Paris-Tech launched its first BIM Master Class in September 2014. In the public sector the Architects Official Training Organization (GEPA) has launched a BIM Manager course and the Trade Union of Architects (UNSA) has formed a BIM School.

The French National research Project MINnd has also been set up which joins together contractors, engineers, software vendors, academia and professional institutes. This two-year programme, led by the buildingSMART French Chapter (AKA Mediaconstruct), is funded by the French Ministry of Industry. A working group, led by the Le Plan Urbanisme Construction Architecture (PUC) has been set up to evaluate lessons learnt on current BIM projects

Germany



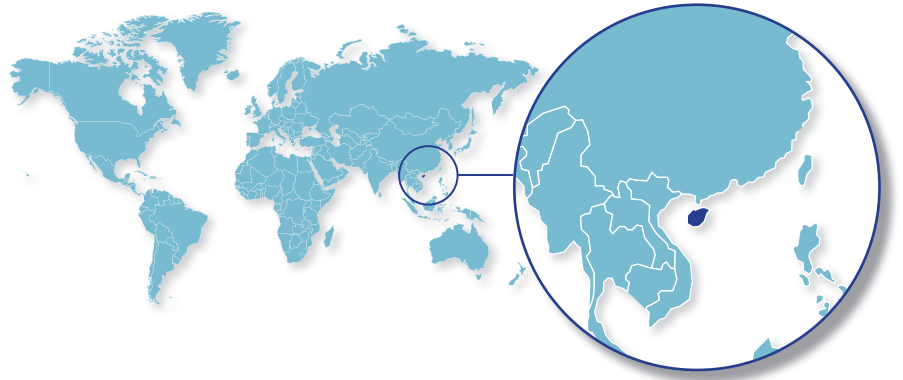
Germany is moving towards a BIM mandate primarily in response to achieving better value on public sector projects as a result of a number of high profile jobs running significantly over budget. Leading institutions and associations from design, construction and operations started the limited company Planenbauen 4.0 “Digitisation of Design, Construction and Operations” in February 2015. This joint and unique initiative, supported by the German government and the industry, aims to unlock the potential of digital design and construction and make it accessible to all members of the supply chain.

Planen-bauen 4.0 is intended to guide and steer the implementation of BIM, or digital design, construction, operation and asset management across the entire industry in Germany. The plan launched on the 15th December 2015 aims to develop vendor-neutral, non-proprietary and independent technology, processes, solutions and is applicable for all types of projects, all procurement types and forms of contracts and for the entire Federated Republic. The introduction of BIM will be effected through a gradual application over time of Performance Level 1, which is the minimum requirement that is to be fulfilled from mid-2017 onwards in the extended pilot phase, and later from 2020 onwards, by all projects that are to be newly planned.

Regulation	Mandated for 2020
Key Champions	Planenbauen 4.0 DIN VDI buildingSMART (Germany)
Noteworthy Publications	Federal Ministry of Transport and Digital Information, (2015), Road Map for Digital Design and Construction: Introduction of modern, IT-based processes and technologies for the design, construction and operation of assets in the built environment

The German Institute for Standardization (DIN) formed a standards committee “BIM” (NA005-01-39AA) with subordinate working groups in April 2015. The Association of German Engineers or VDI is authorised to produce legally binding standards, such as, the VDI2552 series. VDI2552 will become the German national BIM standard and will be developed in cooperation with the authorities responsible for BIM standardization developed within the DIN. The German Roadmap requires that the academic education of architects and engineers should take account of BIM and the requirements resulting from Performance Level 1.

Hong Kong



In order to address the needs of the Hong Kong construction industry in relation to BIM, a Working Group was established under the Committee on Environment and Technology of the Construction Industry Council (CIC) and chaired by the Hong Kong Housing Authority (NATSPEC, 2015).

In September 2014, the Working Group issued the Roadmap for BIM Strategic Implementation in Hong Kong's Construction Industry. The Hong Kong Housing Authority (HKHA) was one of the first BIM pioneers in Hong Kong with the goal to fully implement BIM for all projects by 2014 (Wong and Fan, 2013). Most major developers have adopted BIM to some extent in Hong Kong and the Real Estate Developers Association encourages their members to adopt BIM. A core reason BIM was mandated was that Hong Kong's construction industry must keep pace with the majority of developed countries. Local AEC companies need trained staff with the relevant skill sets and associated BIM facilities to compete for jobs and projects outside of Hong Kong.

The roadmap outlines a number of initiatives to achieve industry-wide implementation of BIM in Hong Kong. These include Collaboration, Incentive and Proven Benefits, Standards and Common Practices, Legal and Insurance, Information Sharing and Handover, Promotion and Education, Digital Capability, Vendor Support, Risk Management and Global Competitiveness.

Regulation	Mandate in place since 2014
Key Champions	The Hong Kong Institute of BIM (HKIBIM) Hong Kong Housing Authority (HKHA) Real Estate Developer Association buildingSMART (Hong Kong)
Noteworthy Publications	Construction Industry Council, (2013), Roadmap for Building Information Modelling Strategic Implementation in Hong Kong's Construction Industry, V 1.0, September 2014 HKIBIM, (2011), Specification Hong Kong Institute of Building Information Modelling BIM Project Specification, HKIBIM Specification (Rev 3.0)

The HKIBIM BIM Standard establishes a process for adopting BIM on building projects. Clients, project managers, architects, engineers, quantity surveyors, contractors, manufacturers and facility managers can produce a BIM Project Specification with reference to this document. Various Universities and Colleges are providing BIM courses as part of their degree programmes (NATSPEC, 2015). The Vocational Training Council (VTC), including the Institute of Vocational Education (IVE), and HKU Space, are providing a total of 20 BIM related courses either as modules within their construction related Higher Diploma programmes or as individual training courses.

Italy



Italy at present do not have a requirement for a BIM mandate on public works. Despite this, some regions such as Lombardia have tried to introduce BIM as a more rewarding construction methodology (Ratajczak et al., 2015). Other recent initiatives include the launch of the country's first BIM library of Saint-Gobain integrated solutions. This will promote the use of BIM for public building and infrastructural projects and aims to help building professionals reduce errors, save time and money, and improve the efficiency and profitability of their projects.

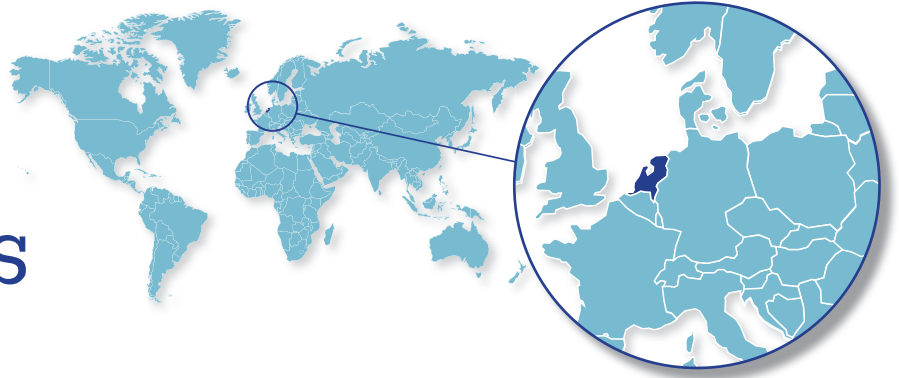
Regulation	No mandate
Key Champions	Institute for BIM Italy (iBIMi) buildingSMART (Italy) OICE
Noteworthy Publications	Parts 1, 4 and 5 of the National UNI 11337

One of the main drivers and promoters of open BIM is the Institute for BIM Italy (iBIMi). According to its website the iBIMi is an association of professionals united by culture, education and the professional practice of activities involving the use of BIM. The Association is open to all those who work and are involved in the field of Open BIM. Other organisations include the OICE which represents the Italian Trade Association for Engineering and Technical-Economic Consultancy who have also done some strong work in promoting BIM. The OICE hosted their International Forum on BIM in April of 2016 in Rome.

Recently the Italian Standard body (UNI) published parts 1, 4 and 5 of the National UNI 11337. These standards address the required digital information management processes for buildings. Other important initiatives include the Italian Government funded research INNOVance project which helped establish the first national database of technical, scientific and economic information useful to the AEC industry (Pavan et al.,2014).

The INNOVance project team consists of 15 major partners, including: some of Italy's largest construction companies; three renowned universities in Milan, Turin, and Naples; all national associations of manufacturers of building components. The project aims to significantly improve energy and overall project efficiency while reducing errors and costs through the expanded use of BIM.

Netherlands



In order to improve quality, continuity and international competitiveness of the Dutch building industry in 2012, the Netherlands set up the Building Information Council (BIR) as part of Rijkswaterstaat highways and waterways BIM programme.

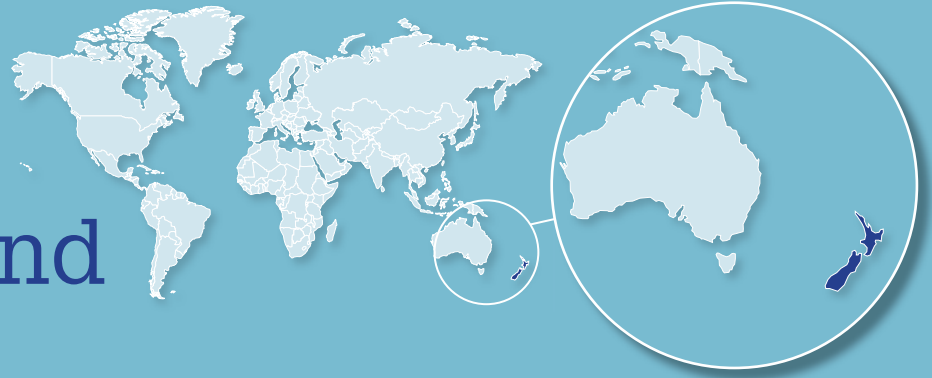
To further stimulate the initiative, a BIM gateway (“BIM Locket”) was developed. BIM Locket is a national direction and coordination platform for the development and management of open BIM standards, including relevant geospatial standards in the country. A few open BIM standards have been successfully adopted to-date, including COINS; which is a BIM standard that complements standards that are released by buildingSMART, VISI; which is the Dutch (open) standard for communications and information transfer in construction projects and CB-NL; (Concepten Bibliotheek Nederland /Concepts Library Netherlands) which is a standard for the digital description of generic reusable concepts related to physically built objects and usable spaces and areas. The creation of the BIM Desk has facilitated the setting up of a central location where each user can create their questions about BIM standards.

Regulation	No Mandate
Key Champions	BIM Locket Building Information Council TNO Boun Informatie Raad buildingSMART (Benelux)
Noteworthy Publications	BIR (2016), National Model BIM Implementation Plan (Nationaal Model BIM Uitvoeringsplan) Release 1.0 – 1 October 2016 Information Modelling BIM Project Specification, HKIBIM Specification (Rev 3.0)

In 2015 the Royal Institute of Dutch Architects (BNA) reported that 76% of architecture practices in the Netherlands were realising BIM benefits. The Netherlands organisation for applied scientific research (TNO) are providing BIM education and research in the Netherlands. Other developments to engage the workforce in BIM education include the BIM Case Week, which is an initiative that brings together professionals in the construction industry for a week to solve problems.

Academic research institutes involved with BIM include the VISICO centre which is based in the Twente University’s Department of Construction Management and Engineering at the Faculty of Engineering Technology. The BIR has issued practical guidance for implementing BIM under the title “On the way to work with BIM”. The Dutch BIM Handbook also provides guidance on BIM in practice. The ongoing largest road reconstruction programme in the country, Schiphol-Amsterdam-Almere (SAA) is fully deployed with BIM with a total budget of €4 billion for the period of 2012-2020.

New Zealand



At present New Zealand does not have a BIM Mandate. A survey by the BIM Acceleration Committee (BAC) of New Zealand reported in 2015 that 45% of projects used BIM. The main barrier identified was the need to link up industry knowledge and expertise to ensure widespread use of BIM. There was also a need to ensure clients were receiving the full value from BIM projects to ensure they continued to include BIM in future projects.

Regulation	No regulation to-date
Key Champions	BIM Acceleration Committee
Noteworthy Publications	BIM Acceleration Committee, (2014), New Zealand BIM Handbook, A guide to enabling BIM on building projects, July 2014.

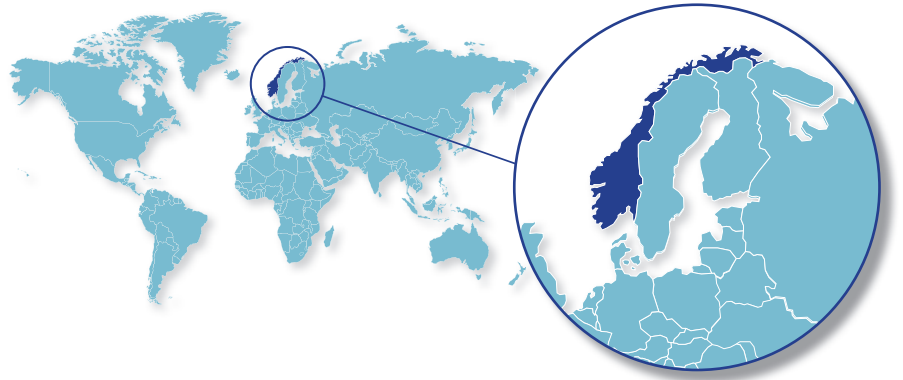
The BAC was established in February 2014 as a designated branch of the National Technical Standards Committee in an effort to develop more efficient work processes through the application of BIM and open standards. The BAC has secured up to \$250,000 for the three financial years ending March 2017 for activities that will accelerate the adoption of BIM. One of the key projects within the BAC is to raise the awareness of BIM, providing a concise handbook for BIM adoption and increase the knowledge of the benefits that BIM brings for major clients and all industry players. The New Zealand BIM Handbook was produced by the BAC to help all professions understand their role.

The BAC handbook outlines that the industry is moving towards BIM, primarily by a desire to document projects more efficiently. An increasing number of projects are requiring the contractor to maintain the BIM model throughout the construction phase and provide an As-Built or Record Model at handover.

This Handbook aims to aid the further development of this process by increasing client's understanding of the benefits of BIM, so that they can better brief their design teams. Other objectives involve creating a common language for professionals and outlining the process that should be followed to efficiently implement BIM on a project.

The BIM Handbook provides a solid framework for deciding whether to use BIM with a total of 21 defined uses. Importantly, it also introduces a common language around BIM. Other working groups include BIM AK in Auckland, BIM.well in Wellington and BIMsiNZ in the South Island.

Norway



A slump in the Norwegian construction market during 2013 resulted in a requirement for BIM adoption which was seen as an enabler of growth to assist in the recovery of the industry.

The Norwegian government established its national mandate in 2016 to reduce errors, improve coordination, increase energy efficiency of its buildings and in general gain efficiencies. A joint statement which set out particular requirements for all project participants to use open standards by July 2016 was signed by a number of large public sector clients, which included the Norwegian Defence Estates Agency (NDEA), Helse Midt-Norge RHF (Central Norway Regional Health Authority), Helse Sør-Øst RHF (South-Eastern Norway Regional Health Authority), and Statsbygg (Directorate of Public Construction and Property). The Norwegian Homebuilders Association (NHA) has encouraged the industry to adopt BIM and IFC. They produced a BIM Manual in 2011 intended to be a practical aid for those who perform the project planning for residential dwellings.

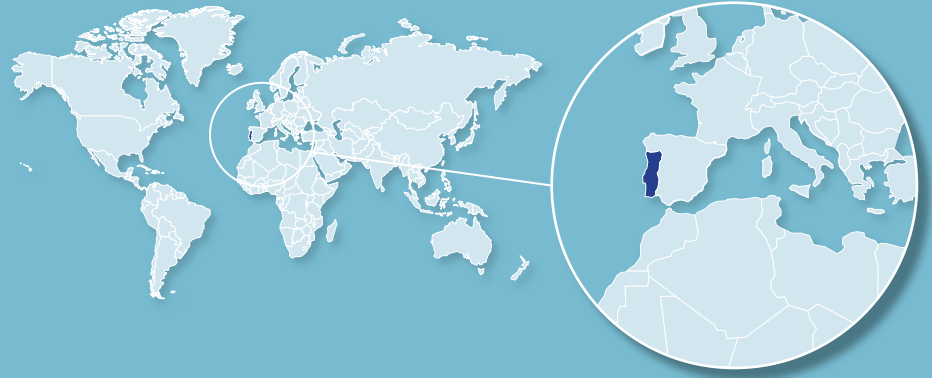
Regulation	Mandated in 2016
Key Champions	Statsbygg buildingSMART Norway Norwegian Homebuilders Association
Noteworthy Publications	Statsbygg BIM Manual 1.2.1 (2013) Norwegian Home Builders Manual Version 1.0 (2011)

By 2015 Statsbygg, Norwegian Defence Estates Agency and major hospitals required BIM for all national public projects, with additional BIM data requirements in 2016.

Norway's BIM guidelines are called the BIM manual. The aim of the guidelines is to describe Statsbygg's requirements dealing with the adoption of BIM. This manual which was originally for Statsbygg's use is now being used by other parties in Norway (Wong et al. 2009).

In March 2015, buildingSMART Norway (bSN) released a BIM Guideline database.

Portugal



At present there is no mandate in Portugal for BIM but standards are being developed. BIM is changing the Portuguese construction industry's mentality with existing BIM knowledge beginning to change the industry's perspective (Costa, 2016). Silva et al (2016) recommended that the Portuguese government should consider a possible mandate to maintain the competitiveness of services in the region. A proposed roadmap aims to realise the vision of a highly integrated and technologically advanced construction sector that will be led by progressive firms and supported by a skilled and competent workforce during the 2020s. Costa (2016) also believes that the growing awareness with regards to BIM will eventually lead to the development of a national digital plan for construction.

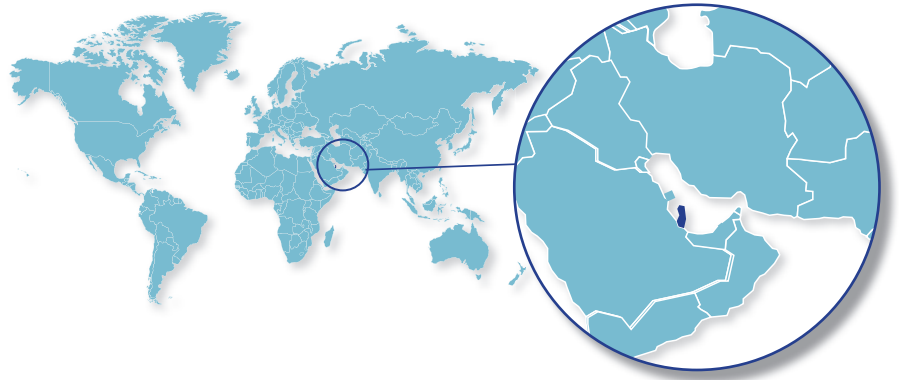
Regulation	No BIM requirement planned
Key Champions	Technical Committee for BIM standardization, CT 197 - BIM BIMCLUB University Initiative BIM task group of the Portuguese Technology Platform for construction
Noteworthy Publications	CT 197 have published a "Vision" and an "Action Plan" to support industry's efforts.

Despite the absence of a mandate there are strong elements of ICT within the public sector, as seen through the adoption of e- Procurement for all open, restricted or negotiated public procurements, which is mandatory. The Portugal Public Contracts Code was approved in 2008 and mandates public e-procurement in Portugal (Costa and Grilla, 2015).

Organisations working to promote and accelerate the adoption of BIM in the Portuguese construction industry include the Technical Committee for BIM standardization (CT 197 – BIM). The CT197-BIM committee has developed the first strategic document for construction 4.0 in Portugal. The proposed vision is based on five dimensions, which support the definition of short, medium and long-term goals (Costa, 2016).

The BIMCLUB Universities initiative was set up to the establish a virtual platform for informal discussion and promotion of initiatives related to the implementation and dissemination of BIM in a university context, particularly aimed at students and teachers.

Qatar



During the past year, there has been a gradual increase in the maturity of BIM and related technologies in the Qatar region.

The landscape of Qatar is changing rapidly with a proliferation of mega projects underway as part of its National Vision 2030. The nature and size of the projects means that Qatar has turned to BIM to facilitate its ambitious building schedule.

Doha's new Metro System and the numerous sporting stadiums to be built in preparation for the FIFA World Cup in 2022 gives a flavour of the projects that will be utilising BIM. Many of these projects will follow the protocols defined by the American Institute of Architects (USA) or the British Standards Institute publication of PAS 1192-2 (UK).

Regulation	No regulation to-date
Key Champions	Q BIM Future BIM Implementation Qatar 2017
Noteworthy Publications	Unknown

There is a vibrant programme of conferences designed to showcase BIM in Qatar, such as, BIM User Day 5 held in November 2015 at Qatar University and the return of the Future BIM Implementation conference in March 2017.

In recent years the Qatar BIM Guidelines Focus Group was formed with several meetings of the group hosted by Professor Nashwan Dawood (Teesside University) and other researchers affiliated with Qatar University BIM group, whose research is supported by the Qatar Foundation. The group recently adopted the name "Q-BIM" with a mission "to promote opportunities to support, connect and grow BIM standards, through lobbying, mentoring, networking, strategic alliances, and developing and recognizing excellence in BIM."

The Future BIM Implementation Qatar Conference 2017 has also been launched to support optimisation of BIM implementation to improve the management of complex construction and infrastructure projects and to address the growing use of BIM technologies in Qatar.

Scotland



A review of the Scottish Public Sector Procurement in Construction was published in October 2013. The review made a number of recommendations on how Scottish public sector procurement could be improved.

A key recommendation within the Scottish Government's construction procurement review was the implementation of BIM to Level 2 by April 2017. In order to achieve better value during procurement through BIM, the Scottish Government has engaged with the Scottish Futures Trust (SFT) to deliver the recommendations.

Regulation	Mandated for 2017
Key Champions	Scottish Futures Trust
Noteworthy Publications	Scottish Futures Trust, (2015), Building Information Modelling (BIM) Implementation Plan, September 2015

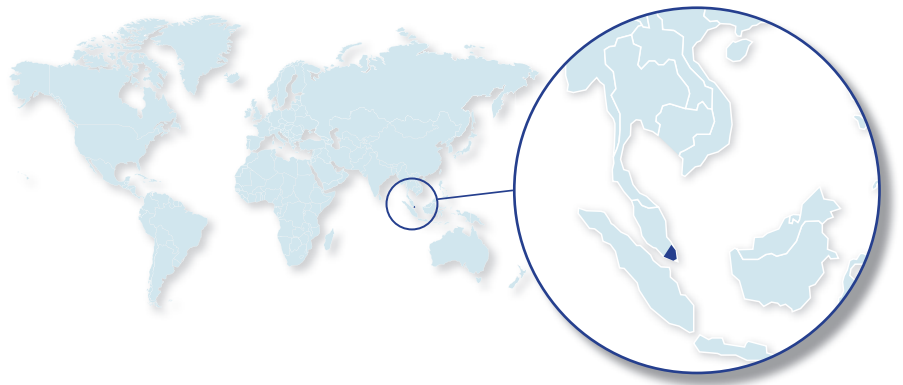
The Scottish BIM Implementation Plan involves five horizons. These horizons are (1) plan and launch, (2) mobilisation, (3) pathfinder projects, (4) BIM guidance and (5) launch of BIM Level 2. At present the delivery group is recommending that BIM Level 2 be required for all projects above the current Official Journal of the European Community (OJEU) threshold of £4.32m.

To achieve a Level 2 adoption, they have developed the BIM Level 2 Grading Tool which helps one to understand when to adopt BIM Level 2. BIM centres have been established to drive the education of BIM, with the Glasgow Caledonian University setting up a dedicated BIM centre where experts, in partnership with industry, clients and standard setting organisations are developing knowledge on the implementation of BIM practices.

The first project to be deployed as a BIM pathfinder project is the National Pain Management Centre which is a joint development between NHS Greater Glasgow and Clyde and National Services.

In Scotland two tools have been created to help the AEC sector evaluate the potential benefits of BIM. The BIM Level 2 Benefits Tool explains the potential benefits of implementing BIM and will produce a return on investment scorecard based on inputted information. Another tool, the BIM Compass is a simple, unambiguous and confidential way to assess one's current BIM capability and compare against industry benchmarks.

Singapore



In Singapore the Building and Construction Authority (BCA) had a roadmap for BIM that pushed its construction industry to be using BIM widely by 2015. A related, major initiative of the government is to improve the construction industry's productivity through the use of BIM by 20-30%.

The government's long term goal is to create a highly integrated and technologically advanced construction sector led by progressive firms and supported by a skilled and competent workforce by 2020. To incentivise early BIM adopters, it introduced a \$6-million BIM fund in June 2010 to cover costs of training, consultancy, software and hardware with Singapore universities encouraged to offer courses on BIM and organise BIM workshops and seminars regularly (Khemlani, 2012). A second BIM roadmap has been realised to further productivity within the public sector. The government has also established a Construction Productivity and Capability Fund of \$250 million with a key BIM target. The Fund comprises of incentive schemes that focus on workforce development, technology adoption and capability development in Singapore's built environment.

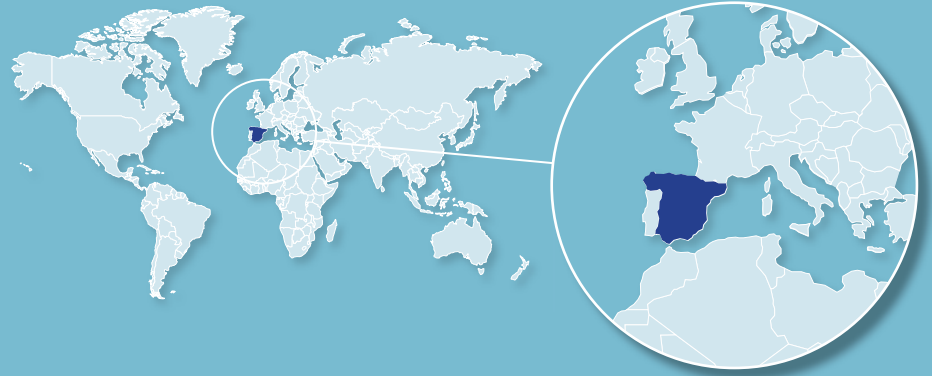
Regulation	Mandate in place since 2015
Key Champions	Building and Construction Authority buildingSMART Singapore
Noteworthy Publications	Building Construction Authority, (2013), Singapore BIM Guide Version 2.0, August 2013

In Singapore, Construction and Real Estate Network (CORENET) is the main organisation involved in the development and implementation of BIM for government projects. It is a major IT initiative that was launched in 1995 by Singapore's Ministry of National Development (Wong et al, 2009). The CORENET e PlanCheck defines Singapore's Automated Code Checking System and several authorities in Singapore are participating in the e submission system, which requires the use of BIM and IFC.

Since 2011, the BCA has started to accept Architectural, Structural and Mechanical Electrical Plumbing (MEP) BIM e- Submission on its CORNET portal. The BIM Guidelines called "Integrated plan checking" has now been completed. BCA and buildingSMART Singapore have also developed a library of building and design objects, as well as, project collaboration guidelines.

Many of Singapore's universities and polytechnics are involved with BIM training and education.

Spain



A strategy to introduce mandatory BIM in public sector projects was launched in Spain in 2015. A provisional timetable has been set, with recommended use of BIM in public sector projects by March 2018 and mandatory use in infrastructure projects by July 2019. The mandate will apply on public infrastructure that costs in excess of €2 million.

A steering committee called Comisión para la Implantación de la Metodología BIM (Commission for the implementation of BIM methodology) has been set up to promote the implementation of BIM in the Spanish construction sector. The steering committee will in turn set up five task groups. The first is an international liaison task group, which will aim both to align Spain's work on BIM with that of other European countries and to share its experiences with countries in Latin America. The other four groups will deal with strategies, technologies, people and processes.

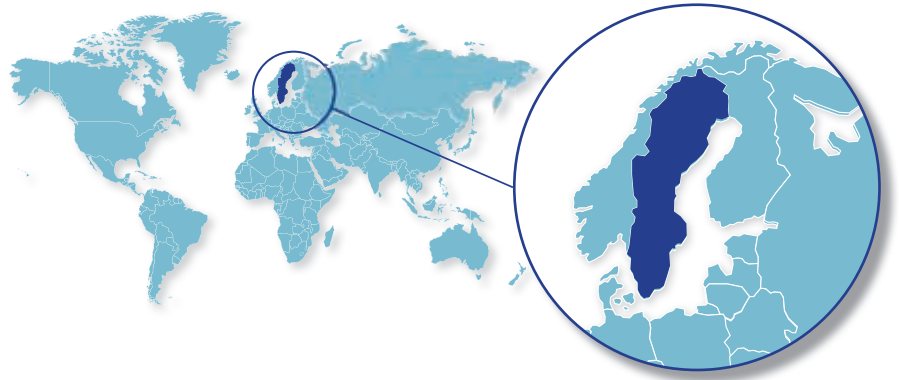
Regulation	Mandated for 2018
Key Champions	Comisión para la implantación de la metodología BIM buildingSMART Spain Standardization Committees AEN/CTN 41/SC13
Noteworthy Publications	Unknown

The strategies will require the mandatory use of open BIM. The Technical Committee is the body responsible for coordinating the Working Groups and managing their relationships with the Commission. The commission's other responsibilities include to promote the implementation of BIM in the Spanish construction sector, promote its use throughout the lifecycle of infrastructure, develop awareness of public administration in establishing BIM requirements in tenders for infrastructure, develop national standards and make a homogeneous academic training map of this methodology in Spain.

The Standardization Committees AEN/CTN 41/SC13 were set up for organising information model standards for building and civil works.

In the academic field, the Polytechnic University of Valencia agreed to publish an academic BIM manifest, so as to establish a training plan for integrated and collaborative BIM among all academic institutions. The plan aims to improve the training of students, teachers and professionals in the construction sector.

Sweden



Sweden has initiated efforts to increase a nation-wide implementation of BIM. This led to the launch of the non-profit organisation OpenBIM in 2009 to establish BIM standards in Sweden (Sanchez et al, 2014). OpenBIM, now incorporating other related organisations including the local chapter of buildingSMART, has re-branded itself as BIM Alliance Sweden (Hooper, 2015). The BIM Alliance Sweden is a non-profit organisation that promotes implementation, management and development of common open standards, processes, methods and tools. Approximately 170 companies and organizations are members. In June 2013, they published a BIM guideline, called 'BIM – Standardiseringsbehov' to assist in promoting BIM adoption. More recently they supported an SBUF (Development Fund of the Swedish Construction Industry) project titled BIM Standardisation Needs. The final report recommends a comprehensive set of 10 BIM Standardisation Initiatives set (Hooper, 2015).

Regulation	Mandated for Swedish Transportation Administration
Key Champions	BIM Alliance Sweden buildingSMART Nordic
Noteworthy Publications	SBUF, (2013), BIM – Standardiseringsbehov, Edited by Anders Ekholm, Håkan Blom, Klas Eckerberg, Kurt Löwnertz, Väino Tarandi, 20th June 2013.

Whilst BIM is not mandatory in Sweden, five public companies (Akademiska Hus, Fortifikationsverket, Riksdagsförvaltningen, Specialfastigheter Sverige and Statens Fastighetsverk) are collaborating to establish demands and standards regarding BIM adoption on their projects. The Stockholm County Council have included BIM deliverables within their Public Private Partnership (PPP) procurement for some projects. The biggest project owner in Sweden, Swedish Transportation Administration, issued a BIM-strategy in 2013 with the aim to include BIM for all new investment projects from June 2015. As part of their strategy, Trafikverket also developed legal guidelines on digital deliveries for construction works. Trafikverket is also part of the EU funded Virtual Construction for Roads (V-Con) initiative, which aims to improve the efficiency and effectiveness of the National Road Authorities by improving data exchange in the civil infrastructure sector (Sanchez et al, 2014).

The largest real estate company Vasakronan has just started to work with identifying demands in relation to BIM supported by the engineering company Sweco. Locum AB represents one of Sweden's largest portfolio (2.1 million m² in the Stockholm region), have worked in partnership with Stockholm County Council to implement BIM (Davis et al. 2015).

Switzerland



The Digital Construction Switzerland Syndicate unites existing institutions, associations and companies with the aim of representing their shared interest in digital construction. The Swiss Society of Engineers and Architects (SIA) occupational group for technology, launched the Digital Construction Switzerland Syndicate together with buildingSMART Switzerland and the SwissBIMalliance.

The aim is to provide the Swiss construction industry with ongoing support in becoming digital and to maintain the industry's competitive position, including on an international level. The working group provides research and guidance within the areas of information, communication, education, knowledge and standardization.

This involves a two phase approach with phase one involving laying the foundations. Phase two involves implementation and development where the entire construction industry will be asked to join the syndicate and play an active part in working towards a digital future.

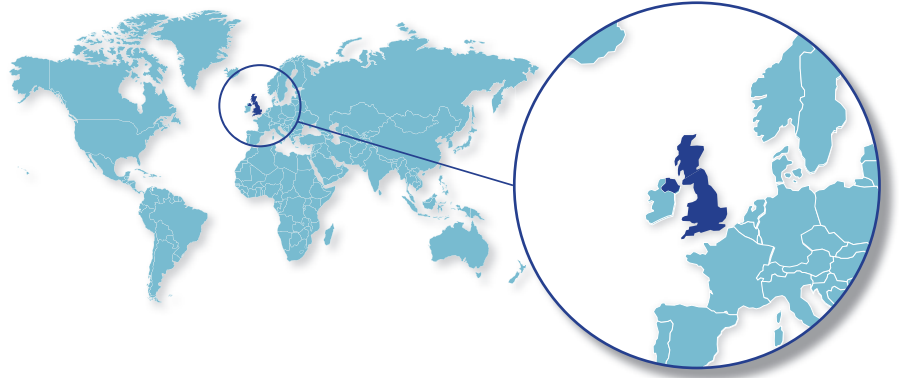
In the Zurich Planergemeinschaft interest in BIM increases which has seen the formation of the SIA Zurich section in the form of a BIM Forum. The forum aims to provide clarity and to investigate the conditions for a successful application of a BIM methodology in Switzerland.

Regulation	No regulation to-date
Key Champions	Digital Construction Switzerland Syndicate buildingSMART Switzerland SwissBIMalliance
Noteworthy Publications	Open BIM Guide for Switzerland (To be published in 2017)

A 2017 Open BIM guide for Switzerland will help users develop a BIM methodology in partnership with existing and regulations of the SIA. This guide promotes the use of open standards.

Recently it was announced that Spitalverband Limmattal hospital group has chosen Bouygues Construction's Swiss subsidiary to deliver a €175m euro hospital using BIM technologies. The project will be one of the first in Switzerland where digital modelling is being carried out collaboratively by architects, civil engineers, HVAC and plumbing specialists.

United Kingdom



The UK Government's Construction Strategy published in May 2011 set out an aim to reduce the cost of public sector assets by up to 20%. To achieve this the government introduced a mandate requiring a minimum of Level 2 collaborative BIM on all centrally funded public projects by 2016. This mandate came into effect in April 2016. The government also established a dedicated BIM Task Group to assist in delivering this aim by providing support to the government and construction industry.

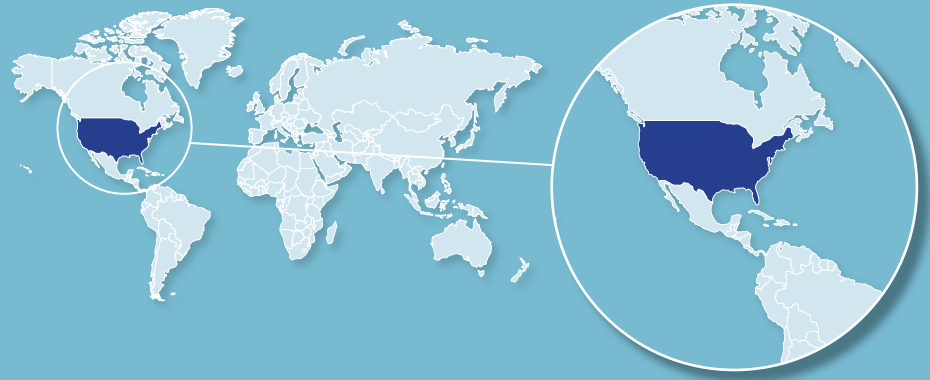
Regulation	Mandated since 2016
Key Champions	UK BIM Alliance Construction Industry Council UK BIM Task Group buildingSMART UKI
Noteworthy Publications	Cabinet Office (UK), (2011), Government Construction Strategy, UK Government Cabinet Office, London BSI, (2011) A report for the Government Construction Client Group. Building Information Modelling (BIM) Working Party strategy paper, 2011 BSI, (2013), PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling

In 2013 the British Standards Institute (BSI) released a PAS (Publicly Accessible Standard) which was sponsored by the Construction Industry Council (CIC). PAS 1192-2:2013 'Specification for information management for the capital/delivery phase of construction projects using building information modelling' was developed as an industry standard to provide specific guidance for information management requirements associated with projects delivered using BIM (BSI, 2013). Alongside PAS 1192-2:2013, there has been a range of supporting guideline documentation published including; Employers Information Requirements; CIC BIM Protocol, 2013; Outline Scope of Services for the Role of Information Management, 2013 and COBie-UK-2012, UK edition of the schema for Construction Operations Building Information Exchange.

The result of the efforts by the UK BIM Task Group, BSI, and the CIC is evident in the 2016 NBS UK BIM survey. The survey found that 54% of construction professionals were using BIM in the industry which was a 23% increase from 2012, with this figure forecast to rise to 86% within one year (NBS, 2016).

A number of educational resources are available to support the BIM Mandate, with organisations such as BRE in the UK offering courses to accredit organisations with a BIM Level 2 standard and third level institutes now offering post-graduate courses in BIM; these include Salford's MSc in BIM and Integrated Design and Middlesex MSc in BIM Management. Further to this, research practices such as the National Building Specification (NBS) have created toolkits to guide professionals through their requirements in the BIM process. Presently the UK is embarking on a level 3 BIM programme.

USA



North America has experienced one of the highest growths of BIM implementation globally, increasing from 28% of construction professional using BIM in 2007 to 71% in 2012 (McGraw Hill, 2013).

BIM in the USA has seen widespread adoption in large public owners, including the General Services Administration (GSA) and the U.S. Army Corps of Engineers (USACE), requiring BIM deliverables on all major projects in the USA. In 2003, the GSA through its Public Buildings Service (PBS) established the National 3D-4D-BIM Programme which has evolved into a collaboration between the Public Buildings Information Technology Services (PB-ITS) and PBS. GSA requires model-based design, including native and IFC BIM deliverables at all project milestones, with any required supplementary 2D deliverables to be derived from the model. GSA also requires open-standard facility management data as a project deliverable at all project milestones. At the same time, all GSA projects are encouraged to deploy mature 3D and 4D BIM technologies to the maximum extent practicable to support specific project challenges and to continue to lead industry in the development and adoption of BIM as a building lifecycle tool.

Regulation	Multiple Mandates through different states
Key Champions	GSA USACE National Institute of Building Science buildingSMART USA
Noteworthy Publications	NBIMS, (2015), National BIM Standard-United States, Version 3, July 2015

The Veterans Affairs Office of Construction and Facilities Management has determined that BIM represents both an enhanced technology and a process change for the architecture-engineering-construction-facilities management industry. New York City Department of Design and Construction and the State of Ohio BIM Protocol both represent BIM mandates in their perspective States. Other public sector mandates include the State of Tennessee Office, Texas Facilities Commission, State of Maryland and Washington D.C. Public Schools, New York School Construction Authority and State of Wisconsin. The USA is the source of important BIM initiatives, such as, COBie and the buildingSMART alliance, the Penn State BIM Task Force and the National Institute of Building Science.

The National BIM Standard-United States (NBIMS-US) provides consensus based standards through referencing existing standards, documenting information exchanges and delivering best business practices for the entire built environment.

Below:
Walt Disney Concert Hall, Los Angeles

Right:
View of Panama City

Bottom:
City of London landscape



The background of the slide is a dark blue world map with a grid of binary code (0s and 1s) overlaid on it. The map is centered on the Atlantic Ocean, showing the continents of North America, South America, Europe, and Africa. The binary code is scattered across the map, with some larger numbers like '10101' and '101' visible.

Overall findings

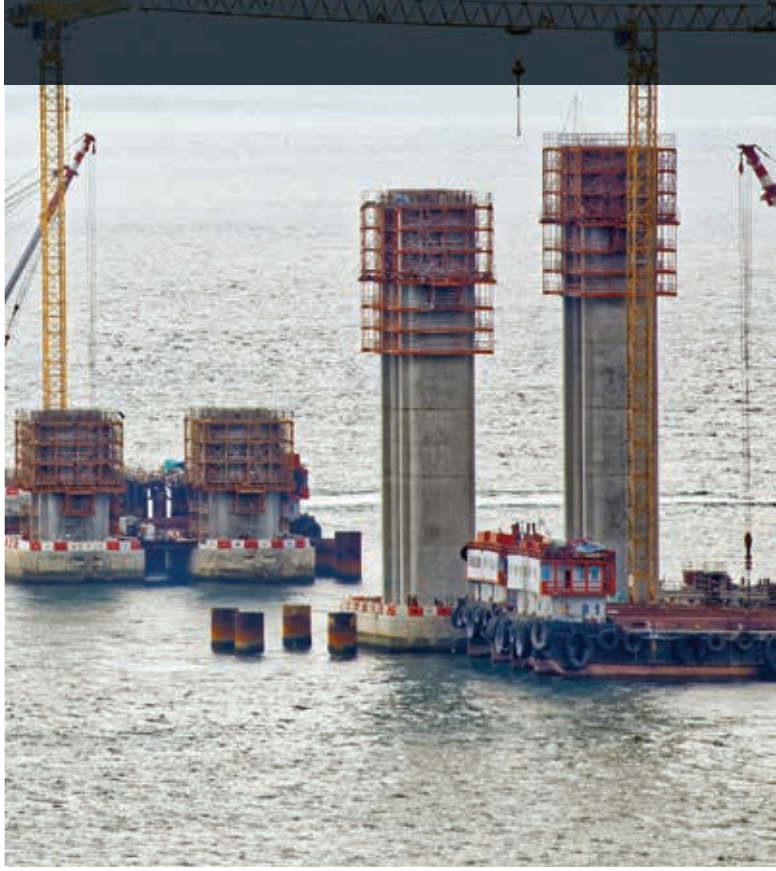
Recurring themes

Lessons for Ireland's
BIM Programme

Below:
Construction works at the Hong Kong–Zuhai–Macau Bridge

Right:
European Parliament in Brussels, Belgium.

Bottom:
Cityscape Hong Kong



Overall findings

There is no doubting the increasing relevance of BIM to the international construction community. Over 50% of the twenty seven countries reviewed in this report have a regulatory requirement for BIM or are planning on implementing one in the near future.

The presence of key champions and drivers of BIM in each country is clearly evident to see with a significant number of countries being influenced by the work of buildingSMART chapters within their regions. Over 60% of the countries reviewed have produced a BIM Guide or Manual to assist in the promotion of BIM locally.

BIM adoption in North America has risen dramatically from 28% to 71% between 2007 and 2012, where adoption by contractors now slightly exceeds that of Architects (McGraw Hill, 2014a). The McGraw Hill (2014b) reported on the business value of BIM in Australia and New Zealand, detailing that despite BIM being relatively new in these countries there was wide-spread recognition of its value, with 74% of firms surveyed stating they will be engaged with BIM on more than 30% of their projects by 2016.

A recent survey by Jung and Lee (2015) put Oceania in fourth place behind North America, Europe and Asia when it came to depth of implementation, level of proficiency and years of using BIM.

McGraw Hill (2015) reported on the business value of BIM in China, which forecasts a 200% increase of Architects at a higher BIM implementation level in the next two years, whilst a second BIM roadmap in Singapore has been realised to further productivity within the public sector.

Our closest neighbour the UK Government has made the use of BIM mandatory for any new central capital funded public sectors projects since April 2016. The UK has issued in tandem with their Level 2 BIM initiative a suite of connected frameworks and guidelines that are influencing guidelines in many other countries. This includes a number of Publicly Available Specifications (PAS) and British Standards (BS) which offer best

practice in information management for the capital/delivery and operational phase of construction projects using BIM. The UK government have more recently embarked on an ambitious Level 3 BIM programme.

Following their ambitious BIM programme, the UK is now recognised as a global leader in the adoption of BIM with wide-scale uptake in recent years.

The consultative process currently underway by the EU BIM Task Group will provide a better understanding of the current status and practices of the member states regarding BIM implementation programmes. This matter, however, is somewhat complicated by the recent Brexit decision.

“Digitalization signifies a substantial economic and social revolution. It changes the conditions for growth, prosperity and the work of tomorrow – and revolutionizes, in a disruptive process, industries and services, value chains and manufacturing processes, innovation and product life cycles”.

Alexander Dobrindt,
Member of the German Bundestag Federal
Minister of Transport and Digital Infrastructure

“The majority of conversations about BIM and BIM requirements today are, in essence, no different than owners’ mandating a specific backhoe to dig a ditch. Innovation does not come from (defacto) proprietary BIM specifications. If, by BIM, we mean objectively-tested, standards-based deliverables enabling Better Information Management, then we may achieve more than the current artisanal geometric renderings and bim buzzword bingo; something of lasting value for our profession and its clients.”

Bill East, PhD, PE, F.ASCE
Owner, Prairie Sky Consulting.

Recurring Themes

Following this initial scoping exercise, a number of common themes became very evident in the countries where BIM programmes were currently under development or where BIM implementation programmes were in their formal implementation phase. A summary of these key themes are shown in Table 2.

Table 2: Recurring Themes

Recurring Themes within International BIM Initiatives	
Procurement	Efforts have been made internationally to align or adjust the various contractual procurement methods in the light of the requirements for more collaborative work-practices. This requires a review of managing risk, intellectual property, insurance and warranty requirements for clients, consultants and constructors.
BIM Guidelines	These guides provide industry and government clients, consultants and constructor on collaborative working, open standards and general alignment with global best practice.
Education	Efforts have been made internationally to develop and roll out a national awareness programme for governmental clients, the development of national BIM curriculum, vocational training and professional development.
Process Data Exchange	Adoption of best practice in respect to open BIM data exchange that will support collaborative working across the project life cycle from early design inception to maintenance and operational phases.
Regulatory Framework	Establishment of a regulatory mechanism or order that requires planners, regulatory bodies, local government and government agencies and departments to require the use of BIM protocols and open standards on all or specific centrally funded projects.
Pilot Projects	Many countries have identified pilot projects, in which to “learn”, “test” and verify the readiness of the above programmes in an economy wide basis.

The theme of cultural change was evident in all of the international programmes reviewed. Beyond the normal design and construction processes, it was evident that there was a necessity to focus on the whole-life performance, including the performance at operational and maintenance phases. Many of the international programmes reviewed had an implementation life-span of between four to six years to provide the time for this cultural change to take hold. It was also evident that a concerted collaborative effort was required by all stakeholders to ensure these programmes were successfully implemented but also closely monitored.

There were many examples of international BIM Manuals or Guidelines referenced in this report that served as a critical important reference for all project stakeholders, particularly in light of the fact that they were specifically drafted for local needs.

Education also proved a key feature in the countries reviewed with increased evidence of third level colleges integrating BIM into their curriculum offerings but also the setting up of specialist education working groups to help create a more consistent BIM education experience. There was also a theme of developing training awareness programmes for government agencies, departments, academia and industry.

The adoption of open BIM standards was prevalent in those jurisdictions where buildingSMART Alliance chapters were active.

A little over half of those countries reviewed are presently regulating the use of BIM on public sector projects with a number of other regions planning to do so in the very near future. These requirements provide for a structured framework to support local government and other regulatory bodies who are required to work with BIM now and into the future.

A key ingredient of many programmes also included identifying and maintaining the BIM transition through the deployment of pilot projects to facilitate a vehicle of learning and verification of improved project outcomes.

“BIM is the first truly global digital construction technology and will soon be deployed in every country in the world. It is a ‘game changer’ and we need to recognise that it is here to stay – but in common with all innovation this presents both risk and opportunity”.

Patrick MacLeamy,
Chief Executive Office at HOK

“The acceleration of the wider digital revolution combined with a shrinking traditional construction workforce are two issues I would highlight as being critical to the future fortunes of the construction industry. One could argue that the ‘stars are aligning’ and now is the time to allow the opportunities from digitisation to offset the risks of continued reliance on labour intensive techniques”.

Mark Farmer,
October 2016

Lessons for Ireland's BIM Programme

There are many lessons that Ireland can take from this global BIM study. Given the proximity and timing of the UK BIM programme and the cooperative efforts of the EU BIM Task Group there is an inevitability that Ireland must embrace a structured BIM programme in the near future.

Whilst this review did not go through any particular national BIM programme in detail, it is the intention to select a number of countries at the next phase of this global BIM study, where BIM is at a particularly mature level, in order to more forensically investigate the individual programme themes identified earlier.

These recurring themes or programmes were presented by the BICP team to the NBC of Ireland, in June 2016. The recommended programmes were presented as enablers that should be considered by the Council in any Irish BIM Programme (see Figure 4 below).

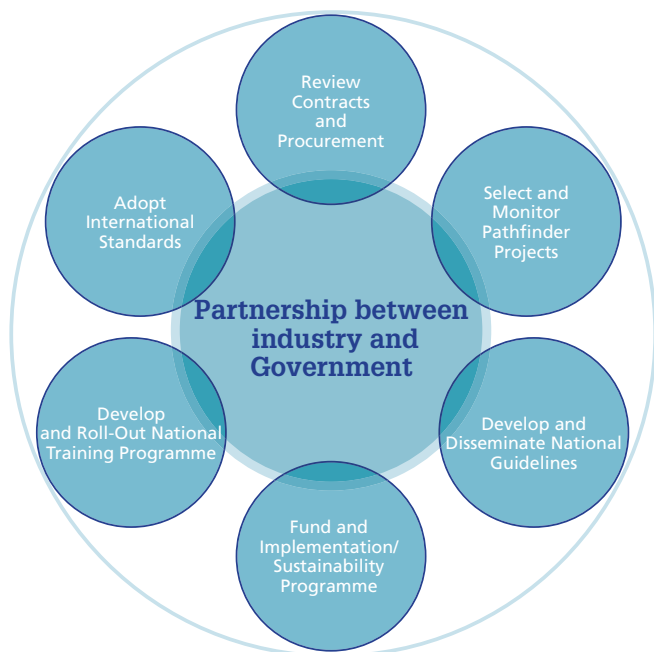


Figure 4
BIM Enablers for Ireland's BIM programme

Contracts and Procurement:

Reviewing procurement routes to ensure the environment is created for BIM processes to work more readily with Irish contracts and procurement procedures.

Pathfinder Projects:

Identify and select suitable national pilot projects to assist in generating data to validate the benefits of BIM on public work projects.

National BIM Guidelines:

Review international BIM Manuals and Guidelines with the intention of developing Ireland's Guidelines to create and implement a collaborative environment that will promote the use of good BIM practice on Irish engineering and construction projects.

Funding:

Develop a value proposition report for the Irish Government and seek a mechanism for funding the implementation and sustainability of a BIM programme for Ireland.

National Training Programme:

Develop and roll out a National BIM training programme for both governmental and industry groups.

International Standards:

With the assistance of the National Standard Authority of Ireland (NSAI) review and contribute to international standards development and recommend (when appropriate) the adoption of BIM international standards in Ireland.

It was recommended that the success of these work packages will be dependent on leadership, expertise, experience and a successful programme of collaboration between government and industry in Ireland.



References



Top:
The Wilshire Grand Centre in California

Above:
The Sky tower in Auckland New Zealand

Right:
The Shanghai Tower in China

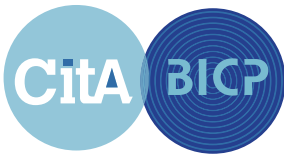


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