



Technological University Dublin  
**ARROW@TU Dublin**

---

Conference papers

School of Multidisciplinary Technologies

---

2020-08-27

## The Irish Construction Industry's State of Readiness for a BIM mandate in 2020

Barry McAuley

*Technological University Dublin, [barry.mcauley@tudublin.ie](mailto:barry.mcauley@tudublin.ie)*


Alan V. Hore

*Technological University Dublin, [alan.hore@tudublin.ie](mailto:alan.hore@tudublin.ie)*

Roger P. West

*Trinity College Dublin, [rwest@tcd.ie](mailto:rwest@tcd.ie)*

Follow this and additional works at: <https://arrow.tudublin.ie/schmuldistcon>

 Part of the [Architectural Engineering Commons](#), [Architectural Technology Commons](#), [Construction Engineering Commons](#), and the [Other Engineering Commons](#)

---

### Recommended Citation

McAuley, B., West, R. and Hore, A. (2020) The Irish Construction industry's state of readiness for a BIM mandate in 2020, Proceedings of the Civil Engineering Research in Ireland 2020 Conference, Cork, 27th - 28th August 2020, pp 740-745.

This Conference Paper is brought to you for free and open access by the School of Multidisciplinary Technologies at ARROW@TU Dublin. It has been accepted for inclusion in Conference papers by an authorized administrator of ARROW@TU Dublin. For more information, please contact [yvonne.desmond@tudublin.ie](mailto:yvonne.desmond@tudublin.ie), [arrow.admin@tudublin.ie](mailto:arrow.admin@tudublin.ie), [brian.widdis@tudublin.ie](mailto:brian.widdis@tudublin.ie).



This work is licensed under a [Creative Commons Attribution-NonCommercial-Share Alike 3.0 License](https://creativecommons.org/licenses/by-nc-sa/3.0/)



# The Irish Construction Industry's State of Readiness for a BIM mandate in 2020

Barry McAuley<sup>1</sup>, Roger.P.West<sup>2</sup> and Alan.V.Hore<sup>3</sup>

<sup>1</sup>School of Multidisciplinary Technologies, Technological University Dublin, Bolton Street, Dublin 1, Ireland.

<sup>2</sup>Department of Civil, Structural and Environment Engineering, Trinity College, Dublin 2, Ireland

<sup>3</sup>School of Surveying and Construction Management, Technological University of Dublin, Bolton Street Campus, Dublin 1, Ireland.

email: barry.mcauley@tudublin.ie, rwest@tcd.ie, alan.hore@tudublin.ie

**ABSTRACT:** It was recently announced that a BIM mandate for the Irish public sector is not imminent, suggesting that the sector is not yet ready for what such a mandate implies. Following on from a forward-looking BIM Roadmap for Ireland in 2017 and the publication by the authors of a detailed BIM in Ireland study in 2017 and 2019, what is the actual state of readiness for a more general BIM mandate in Ireland? This paper will review recent publications, seminars and industry initiatives on this topic of interest supported by an online survey to assess the current state of readiness for a BIM mandate in Ireland. An assessment will be made of what deficits, if any, need to be addressed before the introduction of a BIM mandate would be a practical proposition. Reflections on the success of other similar-sized economies will be referred to in identifying the priorities for Ireland in its preparation for a full BIM mandate, in addition to the relative importance of BIM given the ongoing impact of the CoVID-19 global pandemic on Ireland's economy.

**KEYWORDS:** Building Information Modelling, Construction, Digital, Mandate, Public Sector

## 1 INTRODUCTION

Digital technologies are disrupting the way the Irish construction industry works, and if it is to attract the next generation of professionals and seek out better value-for-money for the taxpayer, it is crucial that the government and the industry stakeholders continue to embrace change [1]. One of the most prevalent digital technologies within the sector is Building Information Modelling (BIM), which is now seen as the centrepiece of the industry's digital transformation [2].

BIM is a collaborative process in which all parties involved in a project use three-dimensional design applications. BIM enhances the current communication process, provides a collaborative platform and supports interoperability between the different business domains [3]. BIM can be applied through the complete lifecycle of a project to evaluate constructability of designs, visualise construction schedules, provide accurate cost estimates and multiple analyses enabling energy and structural performance predictions that can be applied to compare design alternatives [4-6]. However, perhaps the most value to be gained from BIM is within the operational stage because it provides a platform to retrieve, analyse and process building information in a digitalized 3D environment. For public sector bodies, BIM can facilitate the integration of project and asset management services by engaging a more comprehensive range of stakeholders through its processes, which results in innovation in service design and delivery [7].

However, for this to be realised, BIM must be used along with collaborative forms of procurement and change management strategies to support the required transformation [8].

## 2 BIM MATURITY WITHIN THE IRISH CONSTRUCTION SECTOR

Ireland has been active in its BIM journey over recent years, as reflected in a number of important industry reports. The following section represents a chronology of publications,

resources, activities, events and initiatives in Ireland that will be reviewed to understand the state of readiness of the industry for an Irish BIM mandate.

### 2.1 BIM in Ireland 2013 – 2015

In Ireland, the first formal reference to BIM was included in a 2013 *Forfás report*, which focused on Ireland's Construction Sector [9]. Specific mention was made of BIM in the report as an advanced technology that will ensure increased competitiveness and innovation in the sector. Another important initiative launched in 2013 was the Construction IT Alliance (CitA) Technology Pilot. This was a virtual project identified by a team of Irish professionals who wanted to offer the opportunity to experience and disseminate practical lessons on proof of concept and the potential benefits/risks involved in utilising digital technologies [10]. This pilot served as a test bed of BIM technologies and, in doing so, advocated the potential of their application to the sector.

In 2013 CitA also launched the BIM Gathering conference, an international gathering of industry experts and leaders in the areas of Integrated Project Delivery (IPD), BIM and lean construction practices. Further BIM Gathering conferences have taken place in 2015, 2017, and 2019 [11].

In 2014 the *Construction 2020 Strategy* outlined two specific actions, which included implementing a BIM staged development programme to support companies advancing to level 2 BIM capability, which subsequently led to the development of the BIM Enable and BIM Implement support programmes for Enterprise Ireland clients [12, 13]. In a report on the review of the performance of the public works contracts published in late 2014 by the Government Contracts Committee for Construction (GCCC), it was found that risk was not being adequately priced in tenders. The report also included a medium-term strategy with respect to BIM, which recognised BIM as a powerful risk management tool [14].

At the start of 2015, CitA launched its Smarter Building

Cooperative Series, which involved industry associations chairing and contributing to the design and content of the programme. The series is still active and has pivoted towards exploring Modern Methods of Construction (MMC) in 2020. In 2015 CitA also secured funding from Enterprise Ireland for the BIM Innovation Capability Programme (BICP) of Ireland. The BICP sought to capture the capability of the Irish Construction Industry and the Higher Education Institute's (HEI) response to the increased requirement for BIM on Irish construction and engineering projects [15]. An explicit ingredient of the BICP involved assisting the National BIM Council (NBC) of Ireland to develop a national road map to optimise the successful implementation of BIM Level 2 and beyond. In the same year, CitA launched the BIM Regions, the purpose of which was to raise awareness of BIM, promote a shared understanding of the value proposition and share experiences of working with BIM on local projects. A total of 9 regions were launched and are still active in 2020 [16]. BIMireland.ie also launched its flagship website and established a key source for information on BIM and digital construction for the Irish BIM community and BIM enthusiasts [17].

The first national survey to benchmark the level of BIM adoption in Ireland was also launched in 2015 and revealed that 67% of the industry sampled possessed confidence in their skills and knowledge to deliver BIM. The survey targeted the 100 most influential leaders in the Architecture, Engineering, and Contracting (AEC) sector. The survey, which was a joint initiative with CitA and Enterprise Ireland, found that 75% of the sample reported an increase in demand for BIM in Ireland. At the time, the primary barriers to BIM were cost, lack of demand and insufficient training [18].

## 2.2 BIM in Ireland 2016 – 2017

Building on the momentum gained in 2015, the NBC of Ireland was formed in early 2016 with the purpose of providing vision, leadership and a collective voice for the advancement of digital design, construction and operation of built assets [19]. The BICP also launched in May of 2016. The second national survey to benchmark the level of BIM adoption in Ireland revealed that 76% of respondents possessed confidence in their organisation's BIM skills and knowledge. 79% of the sample also reported an increase in demand for BIM in Ireland. The highest-ranked concern involved unawareness of the value proposition of BIM with a need for a cost analysis of the benefit of moving towards BIM processes [20].

In January 2017, the government launched its *Action Plan for Jobs 2017* report. A particular action flowing from this plan included a requirement for the Office of Government Procurement (OGP) and Enterprise Ireland to prepare a strategy for the adoption of BIM across the public capital programme and to mandate the manner in which it was to be adopted across the public sector [21]. The OGP responded through a positional paper by setting different target dates ranging from 12 - 48 months for projects to adopt BIM. These projects range from Band 1, which are of low complexity, such as low-density housing projects, to Band 5, which are complex projects with a specialist operation and maintenance regime, such as acute hospitals [22].

The BICP also published two key documents in 2017, the

*Global BIM Study* and *BIM in Ireland 2017* report. The *Global BIM Study* focused on 27 countries and highlighted the increasing relevance of BIM in the international construction community. Over 50% of countries reviewed had a regulatory requirement for BIM or were planning to introduce one soon. The global BIM review and subsequent findings assisted the NBC in formulating their road map. The *BIM in Ireland 2017* report documented an array of BIM initiatives, activities by BIM champions, promotion of BIM within HEIs, BIM adoption by industry and government leaders [16, 23, 24].

As part of the BICP initiative, a Macro BIM Adoption Study was undertaken in Ireland. This framework consisted of five conceptual models that were utilised to measure macro BIM adoption across the world. These models can be used for:

- Assessing a country's current BIM adoption policy.
- Comparing the BIM maturity of different countries.
- Applying models in developing a national BIM roadmap.

The 2017 results showed that while Ireland was mature for modelling processes and model workflows, it was weak in respect to collaboration processes and policies. Concerns were raised at the time that unless a regulatory requirement for BIM was promoted from within the government, then these critical areas would stagnate or regress. Results also indicated that Ireland's larger organisations or industry associations were pushing the BIM agenda within the industry and not the government, with the policymakers mostly seen as passive. Educational institutes were seen as key partners, as they had responded rapidly to demand by industry for BIM-related education and training programmes despite the absence of a national BIM mandate. Both construction organisations and communities of practice were identified as important key process players, with various BIM Groups set up by professional institutes in Ireland, such as the Royal Institute of Architects in Ireland (RIAI) BIM Committee and the Society of Chartered Surveyors Ireland (SCSI) BIM Working Group, among others [25].

In December 2017 the NBC published the Roadmap to Digital Transition for Ireland's Construction Industry 2018-2021. The roadmap consists of the four parallel pillars of leadership, standards, education and procurement, with particular milestones to be achieved for each of the pillars during the programme period 2018-2021 [26]. The Irish government also announced in the same year its strategy to increase the use of digital technologies, in particular categories of public works projects over a 4-year timeframe ending in 2021. This statement of intent from the Irish government demonstrated an acute awareness of the importance of BIM and how it brings together technology, process improvements and digital information to radically improve project outcomes and asset operations [27].

The third national survey to benchmark the level of BIM adoption in Ireland revealed a rise in the number of organisations that had been impacted by the now extant U.K. mandate. 76% of respondents indicated that they possessed confidence in respect to BIM knowledge and skills, which is similar to the levels recorded in 2016. Client unawareness of the value proposition of BIM and implementing BIM within SMEs remained the top barriers for organisations [28].

### 2.3 BIM in Ireland 2018 – 2019

The industry in 2018 had a renewed focus on BIM as a result of the NBC Roadmap and the government's digital strategy. However, both failed to adequately propel the industry to the next stage due primarily to a lack of funding. Despite this, further governmental reports continued to advocate BIM. The *Action Plan for Jobs 2018* report promoted the central theme that digital technologies are becoming increasingly disruptive and pervasive, in particular, robotics and artificial intelligence, internet of things, augmented/virtual reality, blockchain and digital fabrication. In response, to prepare the sector, the government proposed new pathways for reskilling into ICT/Technology roles at the apprenticeship level and put in place provisions to attract and retain talent [29]. The *Expert Group on Future Skills Needs (EGFSN)*, which advises the Irish government on the current and future skills needs of the economy, highlighted that prefabrication and the use of BIM systems will have a substantial impact on the sector over time. However, they warned that construction has been slow to embrace digitisation and that the structure and risks in current contracts were acting as a barrier to the use of BIM [30].

Such was the popularity of digital construction and BIM by 2018 that a number of award ceremonies had specific categories recognising organisations and projects in BIM excellence, such as the CitA Technology Awards, Irish Construction Excellence Awards and Irish Construction Industry Awards. These awards were strengthened by the ongoing interest from professional bodies organising conferences and CPD events, for example, the CIF Digital Construction Summit.

In 2019 further reports continued to advocate BIM with the *Engineers Ireland State of Ireland 2019* report, including a specific reference to the vital contribution that MMC, including BIM, can play in expediting the delivery of housing provision in Ireland [31]. The *Construction Sector Performance and Prospects 2019* report also called for Ireland's construction industry to embrace digital technologies more proactively [32]. The *Skills for the Construction Sector* group published a report in 2019 that recognised BIM as a powerful tool in driving efficiencies and increasing productivity [33]. In the same year, *Project Ireland 2040* introduced a vehicle to ensure regular and

open dialogue between the government and the construction sector by the establishment of a Construction Sector Working Group (CSG). A part of the CSG's remit was to investigate how industry and Government departments could take forward proposals on BIM [34].

In 2019 the original BICP team reapplied the macro BIM maturity conceptual models to investigate if Ireland's BIM diffusion dynamic and levels had been impacted [35]. The results found that Ireland has experienced a steady increase in both collaboration and integration for processes and policies. The improvement in policy and processes can be attributed to the roadmap, the government's digital strategy and the introduction of ISO 19650. The ISO 19650 documents provide a standardised approach to using BIM for the delivery phase of assets. Learning and education remain strong, with ongoing commitments to digital construction curricula evident within leading third level educational bodies. There has also been a marked improvement in BIM-related research projects [36], such as the Horizon 2020 BIMcert and BIMZeED projects.

Larger organisations or industry associations were still seen to be pushing the BIM agenda within the industry and not the government. This was concerning considering that unless adequate funding is provided to support the government's digital strategy, it may risk further alienating SMEs within an already demanding and extremely competitive sector. The results also showed that despite an increase in objectives and milestones, regulatory frameworks and a move toward an active communication strategy, the industry overall was not satisfied with the government's leadership and support. In regard to the roadmap, there were still many vital objectives outstanding that will need funding if the key targets are to be achieved. These results, along with a broader update on BIM, were published as part of the BIM in Ireland 2019 Report [1].

In the 2019 NBS CitA survey, it was reported that 76% of respondents had adopted BIM [37]. The primary barriers for BIM implementation in Ireland were a lack of in-house expertise (74%), no client demand (67%) and a lack of training (67%). The absence of an established contractual framework for working with BIM was also seen as a critical barrier. Figure 1 illustrates Ireland's BIM journey since 2013, including the principal milestones.

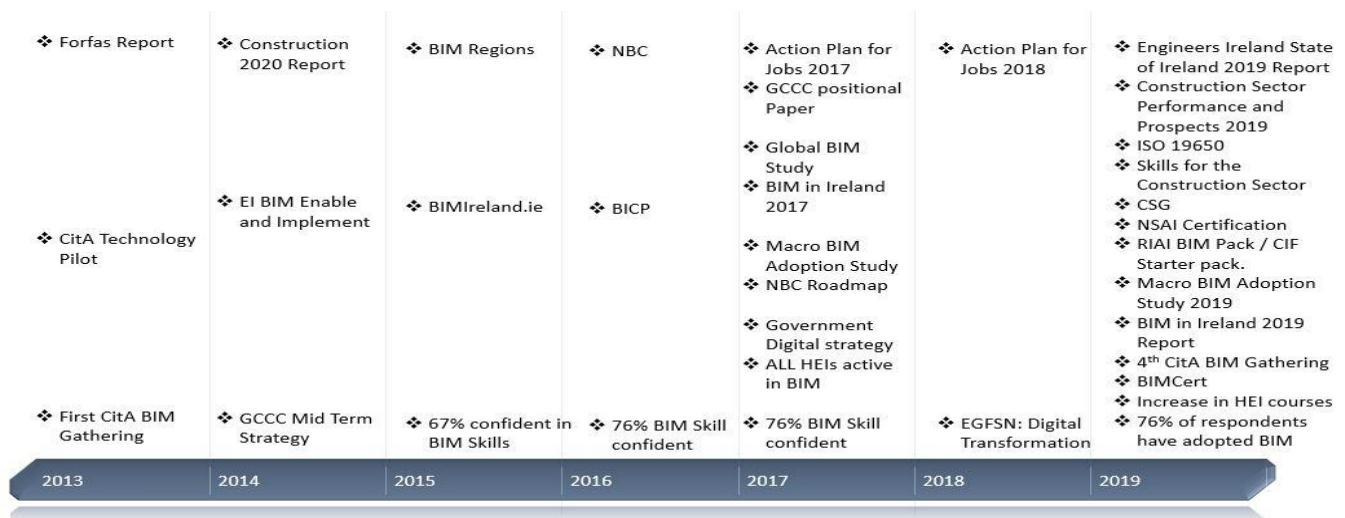


Figure 1: Ireland's BIM journey and key milestones

### 3 BIM IN IRELAND 2020

The results from the previous section demonstrate that construction in Ireland has significantly progressed as an industry viz its level of BIM maturity since 2013. There is an eclectic range of resources in place which has resulted in what would appear to be a high level of BIM adoption within much of the industry, with adoption figures remaining in the high 70 percent range over the last number of years. By all accounts, the Irish construction sector seems well placed to react to a government mandate. However, despite these encouraging findings, there is still no mandate, a lack of funding and chronic barriers remain, such as low client demand and an absence of suitable contractual frameworks. To adequately understand the Irish construction industry's state of readiness for a BIM mandate, the authors conducted an extensive purpose-made survey that targeted a cross-section of the Irish AEC sector. The authors also took the opportunity to elicit sentiment concerning the current impact of COVID-19 and the continued relevance of digitalisation among Irish construction businesses in 2020 and beyond.

#### 3.1 Methodology

The authors agreed that a targeted organisational approach would be the best method of ascertaining the state of the industry. In that regard, well-known professionals within organisations who had specific responsibility for BIM were approached and asked to complete the survey. Each survey target was asked not to share the survey within their organisation so as not to weaken the sample. A total of 150 organisations were targeted across the Irish AEC sector, with a response rate of 41%.

#### 3.2 Survey Analysis

62 organisations responded, with the vast majority of the sample worked in the East of Ireland (74%), with the next largest representative from the Midlands (8%) and North West (5%). The breakdown of this sample regarding organisational size is illustrated in Figure 2. The largest discipline was architects (30%), main contractors (15%), public sector employees (14%), sub-contractors (8%), building service engineers (6%) and structural engineers (5%). The remaining sample consisted of building suppliers, quantity surveyors, consultants and project managers.

Respondents were asked which category of digital readiness would best represent their employer's business, that is, pioneers, advanced, mainstream, or late adopters. The highest category recorded was mainstream (35%), that is, that part of the majority of organizations in the construction industry who embrace digital technology within resource limitations but have

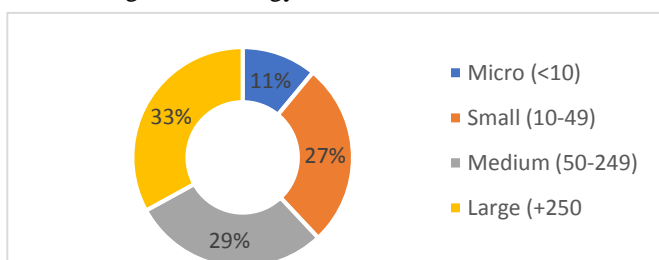


Figure 2: Size category of employer

an appropriate digital presence. Half of the respondents were either pioneers (26%), that is, recognised as digital leaders and drivers in the construction industry or advanced (24%), that is, have the resources to more easily embrace digital and can adapt their business strategy to suit changing demands. The pioneer sample was predominately split between architects and main contractors. 11 % of the sample claimed to be late adopters.

When asked if a BIM mandate is needed on publicly funded projects, all of the sample were in agreement. The key feedback included that a mandate would help to provide a standardised approach that will lead the industry towards a digital transformation. A mandate with specific guidance, templates and contractual obligations would accelerate the levels of adoptions within the industry. Responses show there is concern that organisations are remaining noncommittal and that without a mandate, this position may not change. A further theme that emerged was that public sector clients have a responsibility to adopt digital technologies to meet energy and climate targets, maximise the use of MMC and provide a framework for the sector to move towards a more productive way of doing business. Respondents were largely of the view that a public sector mandate would also assist in driving BIM usage throughout the private sector and show effective leadership

When asked if their business deployed any elements of the ISO 19650 standards, 73% reported its adoption. As this is the internationally recognised standard for data management, its use will, therefore, be a requirement if the government mandates BIM, which indicates that the survey respondents are in a strong position to capitalise on this approach, a possible source of bias in the survey. Despite the perceived importance of standardisation, only 32% of the respondents have secured BIM certification in recent years. The most popular certification amongst the sample was the BSI Kitemark for BIM Level 2. Others included were NSAI EN ISO 19650-2 and BRE BIM Level 2 Business Systems. Many respondents stated that though their organisation had not gained certification, many of their fellow employee's secured individual qualifications, such as the RICS BIM Manager, BRE Individual certification, or are studying for a postgraduate qualification, such as TU Dublin's MSc in Applied BIM and Management [38]. Encouragingly when cross-referenced against organisation size, one could see that SMEs have also sought certification (Figure 3).

Only 17% of the sample had availed of any financial support from Enterprise Ireland under the BIM Enable or BIM Implement programmes in recent years. 28% of the organisations represented were unaware that this funding existed.

When asked about their usage of BIM presently, 42% see it

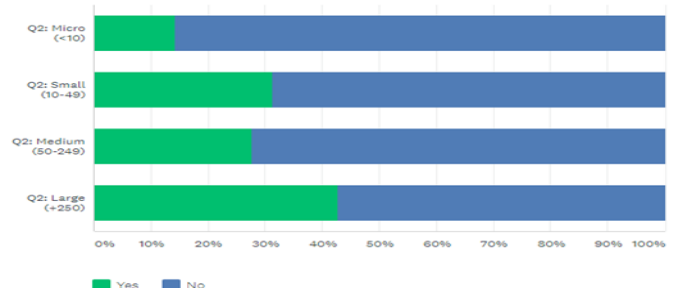


Figure 3: Certification against organisational sizes

as strategically important to their business. A further 32% were aware and regularly used BIM, while 22% did not use BIM extensively. All organisations sizes have a large cohort that either see BIM of strategic importance or are using it extensively. The respondents were asked what deficits, if any, need to be addressed before the introduction of a BIM mandate in Ireland. A total of 52 organisations responded, and a summary of the feedback is categorised under four themes:

- **Vision and Support:** The Irish government needs to communicate a clear and consistent requirement for BIM with a precise scope of works. This must be matched with resources and support for SMEs. This vision must empower local authorities to play a key support role.
- **Standard and Contracts:** The adoption of consistent standards and alignment of procurement frameworks to BIM processes is essential. These new contracts must embrace collaboration and integrated project delivery (IPD). Standards and guidelines should provide a focus on common data environments (CDE), asset requirements, legal protocols, object libraries and exchange information requirements. ISO 19650 was strongly voiced as the preferred standard. The current suite of documents produced by the RIAI was also seen as a viable starting point for a standardised set of templates.
- **Financial Assistance for Hardware and Software Resources:** There must be a reduction in software cost or a contribution towards it. Grants for hardware costs and IT infrastructure must match BIM requirements.
- **Education and Training:** The training of public bodies in BIM awareness with a focus on client requirements is also vital. The upskilling of staff in both associated BIM software and processes is meshed with a call to empower BIM-ready staff to take a leadership role. This training will establish a greater awareness of digital workflows at early design stages. This will help establish a collaborative and consistent approach to data management.

The final question sought to investigate if organisational attitudes towards the importance of digital technology and BIM has changed in light of COVID-19. A total of 62% of the sample indicated that the current crisis had increased the value of digital technologies within their organisation. 60% of respondents who previously stated that they did not use BIM extensively now see digital technologies becoming a crucial part of their business model in the future. Many organisations said that they already understood the critical importance of effective information management; however, with the arrival of the COVID-19 pandemic, this only served to accelerate their digital adoption plans. Some organisations noted that although there is an emphasis on digital technology, such as virtual meeting applications, there has been no push or advancements regarding BIM, as they do not see the value in it. Other organisations which were not as advanced have now experienced the introduction of technology that was previously deemed unnecessary. Upper management has witnessed how online working can enable better remote communication with internal staff and external project participants. BIM has helped in this regard as it allows the team to understand the design intent more easily compared to traditional 2-D drawings.

Despite the findings of this survey, recent reports released in 2020, such as the *Economic analysis of productivity in the Irish construction sector* [41], highlight that a strong appetite to embrace technology advances is evident; however, there has been a low uptake of funding and training supports for technology and innovation development. The CSG has also outlined the need for the industry, particularly SMEs and small firms, to increase investment in innovation and technology to spur the next wave of growth based on a foundation of digital adoption [42]. To achieve this they have made recommendations for the Department of Public Expenditure and Reform to establish and fund Build Digital which will comprise of an online portal which acts as a single source of expertise on BIM, to include advice and guidance, standardised templates and tools, education and training resources. The results from this survey have further reinforced these findings and identify key actions that will be required to ensure a successful mandate.

#### 4 EXEMPLAR BIM PROGRAMMES

While the Irish government must address a series of key actions before a mandate can take full effect, there are other jurisdictions from which they can learn. One of the key requests amongst the survey responses is for a vision, backed by funding, to assist with software and hardware purchases. Lessons can be taken from the UK BIM Mandate, which was endorsed by H.M.'s government in the 2017 Autumn Budget, up to £5.4 million. This enabled a number of commitments to be realised to support the evolution of the successful UK BIM Programme. This is in partnership with the £16 million in funding released in 2016. The Construction Scotland Innovation centre received almost £11 million of core funding to support the sector to innovate, modernise and grow from government funding. The Scottish Futures Trust (SFT) was given the responsibility of managing the Scottish BIM programme and has delivered a plethora of resources primarily available through their open BIM portal. The Finnish Government KIRAdigi programme helped to digitise the construction industry using a total budget of €16 million, with 50% matching funding by industry. The French digital transition plan received €20m in funding and was designed to support the transition of all construction sector bodies that participated in the programme [39, 40].

This funding, received from the respective governments, has helped provide the education and training that has proved vital for these international AEC sectors. It has enabled guidelines and templates to be created that have assisted in creating a clear vision and understanding for all involved. Portals, such as the one established by the SFT, have provided key resources for SMEs that have secured a gateway for them to begin their BIM journey.

#### 5 CONCLUSIONS

This paper has highlighted that the Irish construction industry is adequately positioned to respond to a mandate, as there are already in existence training solutions from HEIs and software providers, industry roadmaps, CPD events, internationally recognised conferences, certification routes, as well as templates and guidance documents. These are all complemented through a broad selection of government

publications all endorsing BIM. Industry and academic publications, research outputs, seminars and workshop presentations have been promoted through professional institutions. With the current Covid-19 crisis, organisations are accelerating their digital agendas and beginning to realise the relevant benefits that digital tools can offer them. This, by default, has further positioned the industry to respond positively to a potential mandate. With these resources and frameworks readily in place, the next step is the delivery of a clear and concise vision from the government that will need to be backed by a roadmap, standards, guidelines and legal protocols. These, it could be argued, are largely in place through existing ISO standards, institutional templates, and the NBC Roadmap and any shortfalls in this respect could be developed in the interim until a mandate is invoked. These resources could also provide the initial starting point for the proposed Build Digital initiative. The most critical factor for the mandate to be successful is adequate funding, with a focus on providing guidance and training resources for clients and SMEs.

## REFERENCES

- [1] McAuley, B., Hore, A.V. and West, R.P. (2019) BIM in Ireland 2019, CitA Ltd.
- [2] World Economic Forum (2018) An Action Plan to Accelerate Building Information Modeling (BIM) Adoption, Shaping the Future of Construction, World Economic Forum.
- [3] Alashmori, T., Othman, I., Rahmawati, Y., Amran, M., Sabah, S.A., Rafindadi, A.D. and Mikic, M. (2020) BIM benefits and its influence on the BIM implementation in Malaysia, *Ain Shams Engineering Journal*.
- [4] Zhang, C., Zayed, T., Hijazi, W. & Alkass, S. (2016) Quantitative Assessment of Building Constructability Using BIM and 4D Simulation. *Open Journal of Civil Engineering*, pp. 442-461.
- [5] Ismail, N. A. A., Drogemuller, R., Beazley, S. & Owen, R. (2016) A Review of BIM Capabilities for Quantity Surveying Practice. Selangor, Malaysia, MATEC Web of Conferences..
- [6] Sanhudoa, L., Ramosb, N., Martinsa, J.P., Almeida, R., Barreirab, M., Simõesb, L. and Cardosob, V. (2018) Building information modelling for energy retrofitting – A review *Renewable and Sustainable Energy Reviews* 89 (2018) 249–260.
- [7] Gao, X. and Bozorgi, P.P. (2019) BIM-enabled facilities operation and maintenance: A review, *Advanced Engineering Informatics*, Iss39, pp 227 – 247.
- [8] Brunet, M., Motamedi, A., Guenette, L.M. and Forgues, D. (2018) Analysis of BIM use for asset management in three public organizations in Québec, Canada, *Built Environment Project and Asset Management* Vol. 9 No. 1, pp. 153-167.
- [9] Forfas Report (2013) Ireland's Construction Sector: Outlook and Strategic Plan to 2015, Forfas.
- [10] McAuley, B., Hore, A.V. and West, R.P. (2015) The Development of Key Performance Indicators to Monitor Early Facilities Management Performance Through the Use of BIM Technologies in Public Sector Projects. *Proceedings of the 2nd International Conference on Civil and Building Engineering Informatics*, Tokyo, 22 – 24th April.
- [11] CitA (2013) The BIM Gathering Conference, proceedings available at <https://www.bimgathering.ie/the-gathering-legacy>.
- [12] Irish Government (2014) Construction 2020: A Strategy for a Renewed Construction Sector, The Stationery Office.
- [13] Enterprise Ireland (2017) Enterprise Ireland Strategy 2017-2020: Build Scale, Expand and Reach, Enterprise Ireland.
- [14] Government Contracts Committee for Construction (2014) Report on the Review of the Performance of the Public Works Contract, Office of Government Procurement.
- [15] BIM Innovation Capability Programme (2016) BIM Innovation Capability Programme for Ireland, available at < [www.bicp.ie](http://www.bicp.ie)>
- [16] McAuley, B., Hore, A.V. and West, R.P. (2017) BIM in Ireland 2017, CitA Ltd.
- [17] BIMireland.ie (2015) About Us, available at <<http://www.bimireland.ie/magazine/about-us>>
- [18] Hore, A.V. and Hunt, J. (2015) First Irish National Survey to benchmark the level of Building Information Modelling (BIM) adoption in Ireland, available at < <https://www.scsi.ie/documents/view?id=744>>
- [19] National BIM Council, (2016) NBC Ireland, available at <<http://www.nbcireland.ie/>>.
- [20] Hore, A.V., Hunt, J. and McAuley, B. (2016) Second Irish National Survey to benchmark the level of Building Information Modelling (BIM) adoption in Ireland, available at < <http://www.bicp.ie/digital-transition-survey>>
- [21] Department of Jobs, Enterprise and Innovation (2017) Action Plan for Jobs 2017, Irish Government.
- [22] Office Government Procurement, (2017) A Public Sector BIM Adoption Strategy: A GCCC positional paper, Government Construction Contracts Committee.
- [23] Hore, A.V., McAuley, B. and West, R.P. (2019) Global BIM Study 2017, CitA Ltd.
- [24] Hore, A.V., McAuley, B. and West, R.P. (2017) BIM Innovation Capability Programme Of Ireland, *Proceedings of the Lean & Computing in Construction Congress (L.C. 3)*, Crete, Greece, 4-12 July 2017
- [25] McAuley, B., Hore, A.V. and West, R.P. (2018) BIM Macro Adoption Study: Establishing Ireland's BIM Maturity and Managing Complex Change, *International Journal of 3-D, Information Modeling*, Iss 7, Volume 1, pp 1-11.
- [26] National BIM Council (2017) Roadmap to Digital Transition for Ireland's Construction Industry, December 2017.
- [27] Government Contracts Committee for Construction (2017) A Public Sector BIM Adoption Strategy, Ref CCP 01/17, 15th March 2017.
- [28] Hore, A.V., Hunt, J. and McAuley, B. (2017) Third Irish National Survey to benchmark the level of Building Information Modelling (BIM) adoption in Ireland, available at < <http://www.bicp.ie/digital-transition-survey>>
- [29] Government Publications (2018) Action Plan for Jobs, published by The Stationery Office.
- [30] Expert Group on Future Skills Needs (2018) Digital Transformation: Assessing the Impact of Digitalisation on Ireland's Workforce, Department of Business, Enterprise, and Innovation.
- [31] Engineers Ireland (2019) State of Ireland, 2019, Engineers Ireland
- [32] Department of Public Expenditure and Reform, (2019) Build Construction Sector Performance and Prospects (BUILD).
- [33] Expert Group on Future Skills Needs (2019) Skills for the Construction Sector: Assessment of 2008-20, Department of Business Enterprise and Innovation.
- [34] Construction Sector Group (2019) A response by CSG industry members to the CSG Sub-Group on Growth & Productivity, June 2019.
- [35] McAuley, B., Hore, A.V. and West, R.P. (2019) BIM in Ireland 2019: A Study of BIM Maturity and Diffusion in Ireland, *Proceedings of the 4th CitA BIM Gathering*, Galway 26th -27th September, pp 222-229.
- [36] McAuley, B., Behan, A., McCormack, P., Hamilton, A., Rebelo, E., Neilson, B., Beckett, G., Costa, A.A., Carreira, P., Likar, D., Taneva-Veshoska, A., Lynch, S., Hynes, W., and Borkovic, T. (2019) Improving the Sustainability of the Built Environment by Training its Workforce in More Efficient and Greener Ways of Designing and Constructing Through the Horizon2020 Energy BIMcert Project, *Proceedings of the CitA BIM Gathering*, Galway 26th September, pp 63-70.
- [37] NBS (2019) National BIM Report 2019: The definitive industry update, RIBA Enterprises Ltd.
- [38] TU Dublin (2020) Applied Building Information Modelling and Management, available at <<https://tudublin.ie/study/postgraduate/courses/building-info-model-manage-applied/>>
- [39] Hore, A.V., McAuley, B. and West, R.P. (2018) Establishing Lessons for Ireland's BIM Policy Through a Systematic Review of International BIM Programmes, *International Journal of 3-D, Information Modeling*, Iss 6, Volume 4, pp 1-14.
- [40] Hore, A.V., McAuley, B. and West, R.P. (2019) Centres of Excellence and Roadmaps for Digital Transition: Lessons for Ireland's Construction Industry, *Proceedings of the 4th CitA BIM Gathering*, Galway, 26th September, pp 247 – 255.
- [41] KPMG, Future Analytics and TU Dublin (2020) Economic analysis of productivity in the Irish construction sector, Department of Public Expenditure and Reform,
- [42] Construction Sector Group (2020) Building Innovation, Department of Public Expenditure and Reform