Integration of Geospatial and Built Environment - National Data Policy

Joint buildingSMART - SIBA Position Paper

July 2015

buildingSMART
AUSTRALASIA

SIBA

17 July 2015

Thank you for the opportunity to present ANZLIC with this position paper prepared jointly by buildingSMART Australasia and the Spatial Industries Business Association (SIBA). We provide the information in our paper entitled "Integration of Geospatial and Built Environment National Data Policy" as support for our argument for a National Data Policy that incorporates framework datasets for the Digital Built Environment.

SIBA and buildingSMART Australasia have come together to create the conversation of the need for a structured environment to support the integration of technologies and processes incorporating Spatial and BIM. The scope of the spatial industry embraces both the built environment and the natural environment, so BIM is of significant interest to SIBA members. Similarly, the scope of the construction industry benefits from technology but is only just starting to understand the implications of not working in a standardised manner with location based data.

This collaboration will form a new Knowledge Community that will embrace current and future stakeholders and lead the way by partnering with Government to dress the challenges and embrace the opportunities of the Digital Built Environment.

Signed and authorised release by:
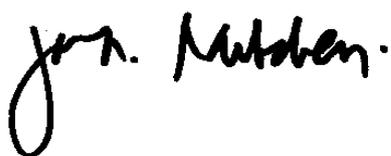
John Mitchell
Chairman
buildingSMART Australasia

Glenn Cockerton
Chairman
SIBA Australia

Table of Contents

Integration of Geospatial & Built Environment - National Data Policy

Executive Summary

Digital technology offers enormous benefits (economic, quality of design and efficiency in use) if adopted to implement integrated ways of representing the physical world in a digital form. When applied across the full extent of the built and natural world, it is referred to as the Digital Built Environment (DBE) and encompasses a wide range of approaches and technology initiatives, all aimed at the same end goal: the development of a virtual world that sufficiently mirrors the real world to form the basis for the smart cities of the present and future, enable efficient infrastructure design and programmed maintenance, and create a new foundation for economic growth and social well-being through evidence-based analysis.

The creation of a National Data Policy for the DBE will facilitate the creation of additional high technology industries in Australia; provide Governments, industries and citizens with greater knowledge of the environments they occupy and plan; and offer citizen-driven innovations for the future.

Australia has slipped behind other nations in the adoption and execution of Building Information Modelling (BIM) and the principal concern is that the gap is widening. Data driven innovation added $67 billion to the Australian economy in 2013[1]. Strong open data policy equates to $16 billion in new value[2]. Australian Government initiatives such as the Digital Earth inspired "National Map" offer a platform and pathway to embrace the concept of a "BIM Globe", while also leveraging unprecedented growth in open source / open data collaboration. Australia must address the challenges by learning from international experiences—most notably the UK and NZ—and mandate the use of BIM across Government, extending the Framework for Spatial Data Foundation to include the Built Environment as a theme and engaging collaboration through a "BIM globe" metaphor.

This proposed DBE strategy will modernise the Australian urban planning and the construction industry. It will change the way we develop our cities by fundamentally altering the dynamics and behaviours of the supply chains and unlocking new and more efficient ways of collaborating at all stages of the project life-cycle.

There are currently two major modelling approaches that contribute to the challenge of delivering the DBE. Though these collectively encompass many (often competing) approaches or proprietary software systems, all can be categorised as either: a spatial modelling approach, where the focus is generally on representing the elements that make up the world within their geographic context; and a construction modelling approach, where the focus is on models that support the life cycle management of the built environment.

These two approaches have tended to evolve independently, addressing two broad industry sectors: the one concerned with understanding and managing global and regional aspects of the world that

---

[1] PWC: Deciding with data: How data-driven innovation is fuelling Australia's economic growth
http://www.pwc.com.au/consulting/assets/publications/Data-drive-innovation-Sep14.pdf
[2] Lateral Economics -Open for Business
https://www.omidyar.com/sites/default/files/file_archive/insights/ON%20Report_061114_FNL.pdf

we inhabit, including disciplines concerned with climate, earth sciences, land ownership, urban and regional planning and infrastructure management; the other is concerned with planning, design, construction and operation of built facilities and includes architectural and engineering design, product manufacturing, construction, facility management and related disciplines (a process/technology commonly known as Building Information Modelling, BIM).

The spatial industries have a strong voice in the development of public policy in Australia, while the construction sector, which in 2014 accounted for around 8.5% of Australia's GDP[3], has no single voice and because of its diversity, is struggling to adapt to and take advantage of the opportunity presented by these digital technologies. The experience in the UK over the past few years has demonstrated that government leadership is very effective in stimulating industry adoption of digital technologies by, on the one hand, mandating the use of BIM on public procurement projects while at the same time, providing comparatively modest funding to address the common issues that confront the industry in adopting that way of working across the supply chain. The reported result has been savings of £840m in construction costs in 2013/14 according to UK Cabinet Office figures[4].

There is worldwide recognition of the value of bringing these two modelling technologies together. Australia has the expertise to exercise leadership in this work, but it requires a commitment by government to recognise the importance of BIM as a companion methodology to the spatial technologies so that these two disciplinary domains can cooperate in the development of data policies and information exchange standards to smooth out common workflows.

buildingSMART Australasia, SIBA and their academic partners have initiated this dialogue in Australia and wish to work collaboratively, with government support and leadership, to explore the opportunities open to us as we develop an Australasian Digital Built Environment. As part of that programme, we must develop and implement a strategy to accelerate the adoption of BIM processes across the Australian construction sector while at the same time, developing an integrated approach in concert with the spatial sector that will position Australia at the forefront of international best practice in this area.

Australia and New Zealand cannot afford to be on the back foot as we face the challenges of rapid urbanisation and change in the global environment. Although we can identify some exemplary initiatives in this area, particularly in New Zealand in response to the need for more resilient urban development in the face of earthquake threats, there is still much that needs to be done. We are well situated in the Asian region to take a lead in this challenge, but we are at imminent risk of losing the initiative if we do not take action now.

Strategic collaboration between Governments, Industry and Academia will create new jobs and wealth, with the potential, for example, to save around 20% on the delivery costs of new built assets, based on recent UK estimates[5].

---

[3] Australian Bureau of Statistics, *Australian National Accounts: National Income, Expenditure and Product, Dec 2014*, Table 6. Gross Value Added by Industry, Chain volume measures, Available On-Line (accessed 11/07/15): http://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/5206.0Dec%202014

[4] Cabinet Office (UK): *Government Construction - Construction Cost Reductions, Cost Benchmarks, & Cost Reduction Trajectories to March 2014*, 2 July 2014, Available On-Line (accessed 11/07/15): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/325919/Departmental_Cost _Benchmarks_Cost_Reduction_Trajectories_and_Cost_Reductions_02_July_2014.pdf

[5] Department for Business, Innovation & Skills (UK): *Construction 2025: industrial strategy for construction - government and industry in partnership*, Policy Paper, BIS/13/955, HM Government, 2 July 2013, p. 19.

Introduction

This paper argues the need for an expanded national data policy that encompasses the growing volume of information that is collected, generated or held in the process of managing the natural and built environment. At the heart of that need are the direct and indirect economic opportunities that would flow from such a policy, providing end to end value across the two sectors.

Broadly speaking, we can identify two industry sectors that jointly contribute the expertise needed to manage the physical environment that we inhabit, and both are accelerating the development of digital technologies and standards to support that work. On the one hand, the spatial sector is traditionally involved in the collection, generation, enhancement and management of spatial and related information used to manage land and broad-scale infrastructure assets, while the construction sector industries focus on the design, delivery and management of built assets, including buildings and all forms of infrastructure.

Both these industry sectors have developed digital modelling technologies that serve as a platform for managing the complex information involved, moving inevitably towards 3D representations in order to better represent the physical world. In doing so, the two sectors have tended to evolve independently, but there is now much debate worldwide on how to bring these two sectors together to establish what is becoming known as the Digital Built Environment (DBE).

The DBE is best thought of as a digitally-constructed virtual world that sufficiently mirrors the real world to serve as the basis for the smart cities of the present and future. It will provide an evidence-based understanding of the built environment that enables efficient infrastructure design and coordinated maintenance, as well as create a foundation for economic growth and social well-being.

There are many economic, cultural and environmental drivers for the development of these technologies, but at the core is the enormous global challenge of rapid urbanisation coupled with depleted natural resources and the demand created by rapidly developing economies. The pressure is on to find smart ways of planning, designing, delivering and maintaining the built environment to meet these challenges.

However, the development of the DBE is about more than just meeting those challenges.

The emergence of the DBE will lead to new economies and employment opportunities as industry responds with innovative and novel ways to take advantage of access to federated data sources that are linked to the physical built environment using RFID tags and sensors. This is widely referred to as the "Internet of Things" and will lead to new ways of interacting with and enjoying the physical world, more sustainable life styles and better-informed planning decisions. For example, recent innovations in tracking public transport to optimise travel choices and the promise of driverless cars to relieve road congestion and increase safety are just the beginning of a set of innovations that will flow from a fully implemented DBE.

To put this discussion in context, we first briefly review the evolution of Building Information Modelling (BIM), the technology used within the construction industry. Figure 1 is a simplification of the BIM Maturity Diagram, first developed by Bew & Richards as early as 2008, showing 4 "levels" of

---

Available on-line (accessed 11/07/15): https://www.gov.uk/government/publications/construction-2025-strategy

development of BIM. As noted, most major economies are currently moving through Level 2. This diagram (in its full form) was adopted by the UK Government as part of its BIM initiative in 2011[6].
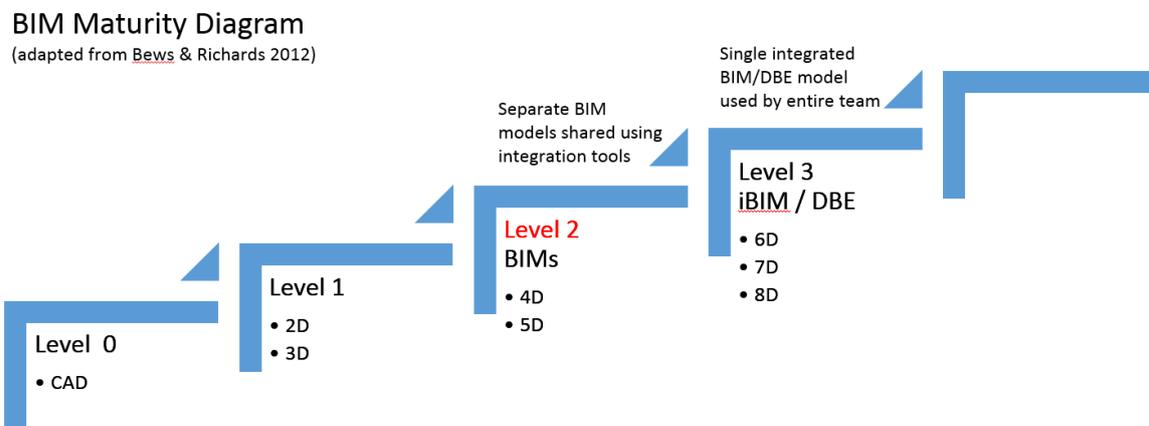

Figure 1 BIM technology is evolving through stages, with most major economies moving through Level 2, and the UK Digital Built Britain strategy targeting Level 3. The DBE would be the culmination of Level 3 in this scheme.

The so-called "dimensions" of CAD/BIM are shown in Figure 1, each associated with one of the levels of BIM maturity. The emergence of CAD appears at Level 0, moving to 2D & 3D CAD at Level 1, but still designing on paper. Level 2 sees the emergence of BIM with 4D integrating time and 5D integrating costs. Later D's (dimensions) build on the earlier dimensions with further analytics, for example: energy (6D); facility management (7D); health and safety (8D); and onwards into the future, reflecting the use of the term 'nD'. These levels of maturity are elaborated further in Appendix A.

The UK is currently leading the world in this effort, beginning in 2011 with the Government Construction Strategy[7] that mandated the use of Level 2 BIM on all public sector projects by 2016. The UK programme is now moving forward into a second phase with the recent announcement (February 2015) of the Digital Built Britain initiative[8]. The stated aim of this latest initiative is "*to make fully computerized construction the norm and ensure that the benefits of these technologies are felt across the UK and support the export of these technologies and the services based on them*" and further, "*to sell [UK] expertise and cutting edge technologies across the world and seize a share of the $15trillion global construction market forecast by 2025*"[9].

Given Australia's position in Asia, we are at risk of losing an enormous opportunity if we do not act now to engage with the opportunities offered by the DBE and "seize our share" of that market, particularly in our own region.

---

[6] Department for Business, Innovation & Skills (UK) Strategy Paper for the Government Construction Client Group, March 2011, p. 40. Available on-line (accessed 17/01/15): http://www.bimtaskgroup.org/wp-content/uploads/2012/03/BIS-BIM-strategy-Report.pdf

[7] Cabinet Office (UK), *Government Construction Strategy*, May 2011. Available on-line (accessed 11/07/15): https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/61152/Government-Construction-Strategy_0.pdf

[8] Department for Business, Innovation & Skills (UK) *Digital Built Britain. Level 3 Building Information Modelling – Strategic Plan*, Policy paper, UK construction industry: digital technology, 26 February 2015. Available on-line (accessed 11/07/15): https://www.gov.uk/government/publications/uk-construction-industry-digital-technology

[9] Ibid, p. 5

Figure 2 is drawn from a recent release of a draft report from the New Zealand Productivity Commission[10]. It espouses the principle that balanced and informed evidence-based decision making on asset management is based on a consideration of data drawn from both the construction ("engineering") and spatial sectors, as well as economic drivers. This stands as an exemplar of the kind of thinking that creates the imperative for the Commonwealth to put in place data policies around the development of the DBE and demonstrates that our nearest neighbour is ahead of us in this area.
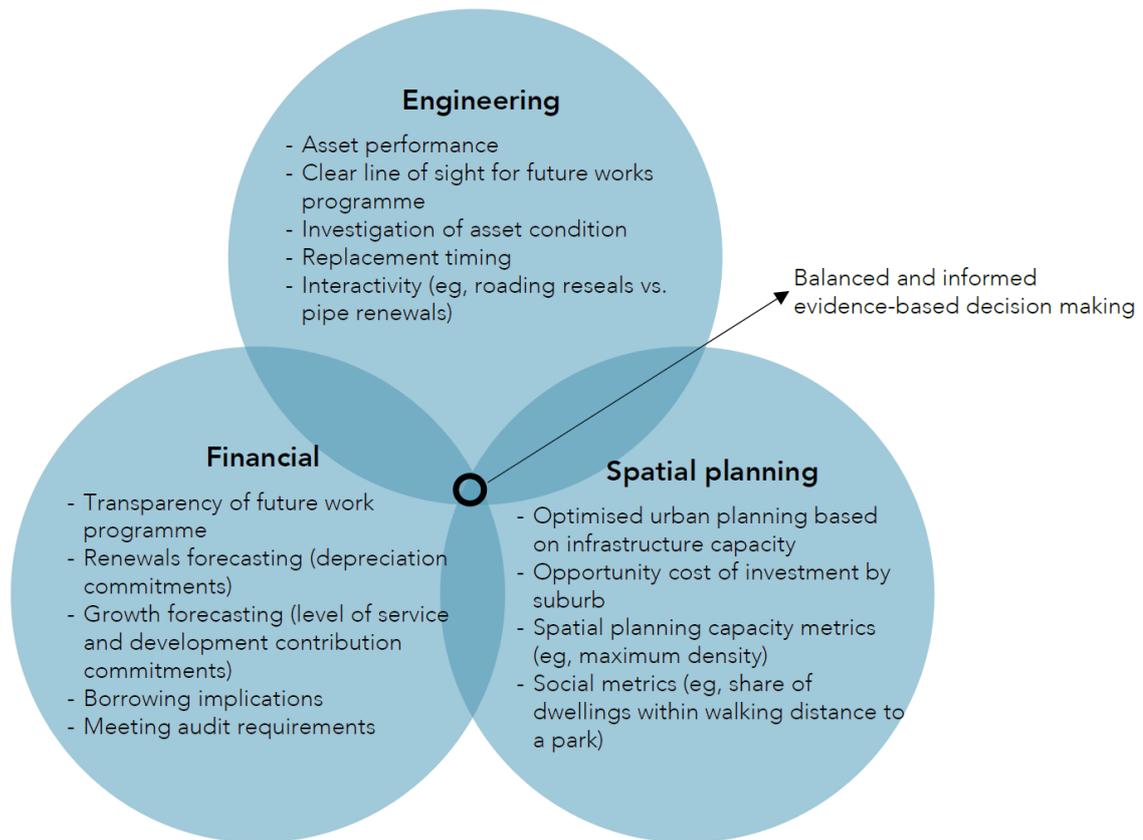
Source: Adapted from Wellington City Council, 2014.

Figure 2 Interdisciplinary collaboration for asset management decision-making (source: New Zealand Productivity Commission, in turn adapted from a Wellington City Council presentation in 2014)

That is not to say that Australia is devoid of any activity in this space. The Federal Government's G20 initiative in creating the Global Infrastructure Hub[11] provides Australia with a platform from which to grow its influence, specifically in developing sustainable, economy-catalysing infrastructure through best practice deployment of digital technologies that ensure the 'bankability' of new work, especially in developing countries.

There is active research being undertaken in this area across Australia. A project funded by the CRC for Low Carbon Living at UNSW Australia is investigating precinct level BIM (coined PIM, Precinct Information Modelling) as a way of promoting collaborative approaches to reducing carbon emissions in the built environment through access to better information. QUT has been identified by the UK Government as one of only five potential international partners to develop Digital Built Britain, as well

---

[10] New Zealand Productivity Commission, Using Land for Housing – Draft Report, June 2015, p. 165. Avaialble on-line (accessed 15/07/15): http://www.productivity.govt.nz/sites/default/files/using-land-draft-report.pdf
[11] http://globalinfrastructurehub.org/files/2015/03/Global-Infrastructure-Hub-fact-sheet-20150305.pdf (accessed 11/07/15)

as by the International Council for Research and Innovation in Building and Construction to lead a global Task Group to develop advanced methods of infrastructure delivery. These activities are strengthened by the Government-sponsored growth in open data programmes in Australia, as well as more focussed initiatives such as AURIN (Australian Urban Information Network)[12] offering the opportunity to link urban research data to the DBE in a holistic manner.

Experience in the UK, the Scandinavian countries, Singapore and other parts of Asia, New Zealand and the US has shown that a little Government leadership, supported by relatively modest investment in the development of standards, data policies, guidelines and the education of the stakeholders, can accelerate the rate at which industry can adapt to the changes necessary to take full advantage of these opportunities.

The time for Government action is now, while the global spatial and construction sectors are looking for a way forward. There are already many examples of Australian companies engaging in innovative practice both here and overseas, demonstrating that Australia has the expertise and capacity to play a greater role in leading the development of the DBE. However, it requires Government commitment and leadership to accelerate that development and capitalise on that expertise. The potential rewards are compelling, particularly in the Asia Pacific region where the need is greatest and the export opportunities for both technology and professional expertise is enormous.

This paper explains the technological platform upon which the DBE can be developed, exploring the nature and structure of information that is traditionally managed across the separate spatial and construction sectors, how that information is used through the digital industries that have evolved within each domain and the benefits that flow from these information management processes. It reviews some of the approaches that are being explored to harmonise those approaches, identifying both the opportunities and challenges, and the role of both industry and government in accelerating that process.

---

[12] http://aurin.org.au/ (accessed 11/07/15)

Background

The adoption of 3D digital modelling technologies is virtually universal in the product manufacturing sector where the investment in design prototyping is not only able to be amortised over large production runs, but manufacturing processes can be controlled directly from the digital model. This is referred to as product modelling and has been in use for more than 3 decades to thoroughly test and refine a product before committing to manufacture. Similarly, the design of complex, mass-produced products, such as cars or aircraft, make use of very detailed digital prototypes to prove a design concept, test performance and refine manufacturing processes. It is a very mature and proven technology in widespread use across the manufacturing sector.

By contrast, the built environment construction sector has been very slow to adopt 3D digital modelling technologies, arguably due to the one-off, site-bound nature of the end product and the fragmented and undercapitalised nature of the construction industry. Figure 3 presents a recent assessment of the worldwide adoption of BIM, indicating that Australia is not as prominent as it might be, in spite of considerable industry expertise in the sector.
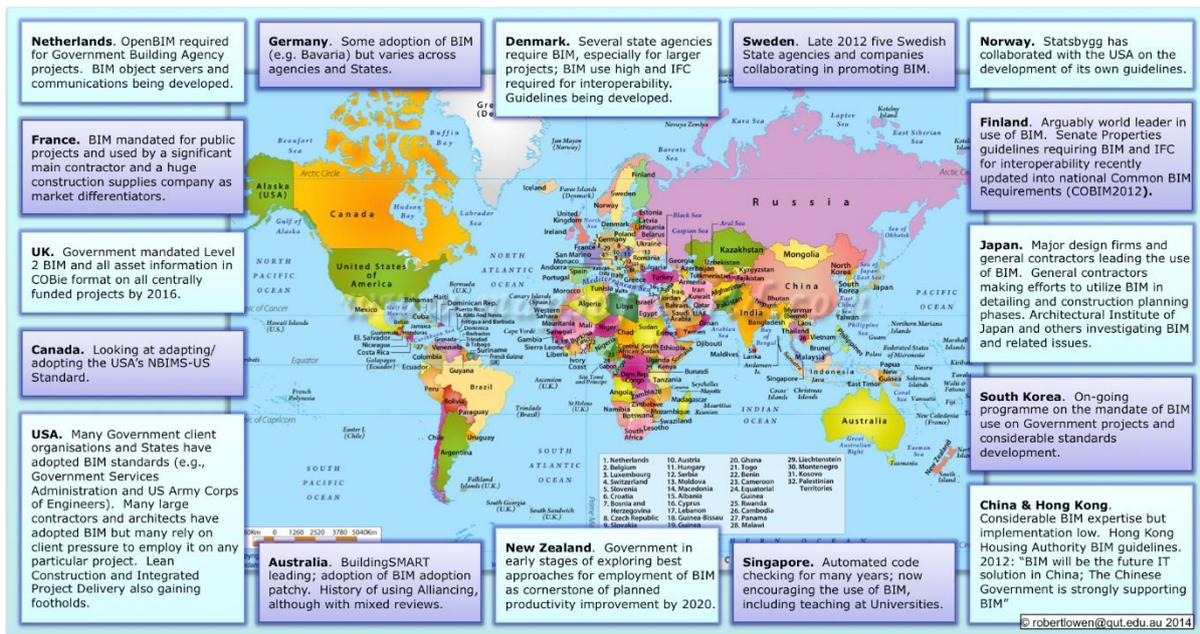
Figure 3 Status of BIM Adoption in different parts of the world (courtesy Robert Owen, QUT)

The technology and processes known as BIM have evolved out of the same concept of virtual prototyping and is beginning to have a transformative effect on the construction sector. Adoption is painstakingly slow for a mature technology due to the nature of construction, but the business case is unassailable and the opportunity for significant productivity savings and design quality benefits is only limited by the industry factors that are impeding its full implementation. This is discussed more fully in later parts of this paper.

The spatial sector has followed a parallel path in the adoption of digital modelling technologies. With an emphasis on planning, management and optimisation of land use at a geographic scale, the traditional approach has been based on a mapping overlay analogy and software applications known collectively as geographic information systems (GIS).

Over time, GIS has been applied in asset management, specifically in defining attribute data and precise location of constructed facilities. The purpose of this modelling approach is the same: creating

a spatial digital model of the real world to provide precise, integrated and holistic views of geographic features within space and time, analyse the interaction between these objects to provide situational awareness, and test and manage scenarios.

The complexity of these spatial models has evolved as computers have become more sophisticated and supporting technologies such as Global Navigation Satellite Systems (GNSS) provide more accurate global positioning capability. In addition recent advances in close range spatial systems such as LiDAR provides greater capability to accurately and comprehensively represent these spatial models in high level 3D detail.

At the same time, the range of natural and man-made phenomena that are represented using these spatial modelling techniques has exploded, along with the emergence of an entire discipline focussed on managing the vast amounts of data that are associated with these features. This forms a significant part of the phenomenon known as big data, and provides an invaluable source of potential "intelligence" about the world we inhabit. As an example of how this is evolving, available real-time data (such as video surveillance or sensor monitoring) is currently very limited in breadth of coverage, quality and update rates. Most often, the data is released in data dumps rather than continuously, and is often degraded before being made available. This is expected to change dramatically in the future, creating real opportunities for innovative use of that kind of information resource.

As these two digital modelling approaches have evolved, they have inevitably begun to converge. BIM methodologies are no longer seen as only applicable to buildings, but are increasingly being used to manage other forms of infrastructure (roads and bridges) and the space between constructed elements, traditionally the domain of landscape architects. At the same time, spatial modelling techniques have begun to focus on greater detail of the features, particularly in urban settings. As noted in the introduction, this convergence is leading to both technology challenges and enormous opportunities as we witness the evolution of the DBE.

These converging digital technologies are elaborated further in the next section of this paper, but it is important to note that one of the key drivers behind both these approaches is their transformative nature when dealing with data. The fundamental intent behind any digital model is to transform the raw data that we collect or create about the natural and built environment into useful information by structuring it within an abstract digital representation. For example, as architects use BIM to work through a design process and make decisions about a proposed building, they are actually recording data (the properties of building elements) in a 3D digital prototype model: we refer to that as an *information model* because it structures the data in such a way that we can gain a deeper understanding of the design by analysing the model, whether through an automated process with a piece of software or by simply examining the model ourselves.

The digital prototype becomes *information* because of the way it is structured, and the analysis process informs our *knowledge* (or understanding) of the proposed design. Similarly, a transport planning consultant uses a GIS application to plot the proposed route of a new highway: by embedding that data into a spatial information model, they are able to gain insights into the consequences and viability of the plan. In both these examples, 3D digital prototypes have become essential tools in the planning, design, adaption, construction and management of the built and natural environments.

The integration of these prototyping approaches opens up a raft of opportunities as innovative software developers create novel ways of manipulating the information available in the DBE to create new insights and knowledge, always enhancing the quality and amenity of the physical built environment. We can extend that vision further if we consider the possibilities provided by artificial

intelligence based systems acting on the information held in the DBE and using machine reasoning to make autonomous decisions and/or inform human decision-making.

Robust, comprehensive information models are not only useful during planning, design and construction of built facilities, but also become invaluable when managing the life cycle of the built environment. This is because they hold, or more precisely, provide access to comprehensive data that can be used creatively to facilitate the way we interact with the world. Sensors of various kinds can be embedded in the physical world to collect real-time data that is used in conjunction with information from the digital model to inform the way we interact and operate within the real world. The concepts of smart cities, smart communities and smart buildings are all examples of pioneering applications of these concepts, but will only achieve their full potential when linked to a fully integrated DBE.

So, why is all this important? Rapid global urbanisation and the need to reduce global carbon emissions are creating enormous challenges that require complex solutions. The development of virtual prototype models of the things that we construct or manufacture has proven to be indispensable for understanding and managing the real world. As spatial and construction information modelling technologies begin to converge, there is a critical opportunity for Australia, through its data policies, to promote the integrated adoption of this way of working across the entire spatial and construction sectors. That would result not only in increased productivity, better solutions and an environmentally sustainable future, but would also establish our leadership in the region and our ability to export Australian expertise and ingenuity to address the critical growth areas within emerging economies. All these lead to financial advantages that accrue both domestically and through export activities.

With that vision in mind, we must not underestimate the challenges involved in bringing those technologies together. We are dealing with a vast diversity of government and private sector stakeholders, spanning almost every discipline, each contributing their bit to the delivery of the built environment and the challenges it brings. This requires bold leadership by Government to give focus to the challenge, plus incentives and resources to drive industry initiatives. While industry will do the heavy lifting in response to economic and market drivers, it can only happen when governments provide the policy frameworks that make the investment secure.

Role of Standards and Protocols

Any strategy to bring these two industry sectors together will rely on the adoption of consistent standards for information interoperability across the two domains, as well as rigorous protocols to control access to information held within the DBE.

There is already a plethora of software tools in both industry sectors that take advantage of digital prototype models, but they are generally locked into proprietary data formats and are unable to share information across software platforms in a reliable fashion. Open information exchange standards exist in both sectors, but their development lags behind proprietary software development because of poor funding. On a project level, industry often relies on proprietary formats because workflow is typically easier if only one proprietary suite of software applications is used by all participants in the project. Robust standards can break this reliance on exclusive proprietary software systems, while encouraging wider commercial software innovation based on those neutral data formats.

buildingSMART Australasia is part of a worldwide industry organisation[13] that has developed open standards for exchanging BIM data (known as IFC) and the processes needed to support collaborative design. The traditional focus of this work has been on buildings, but over the past few years that has

---

[13] http://www.buildingsmart.org/ (accessed 17/07/15)

shifted significantly towards supporting BIM processes for transport infrastructure projects (roads and railways) and civil structures such as bridges and tunnels. This shift is in response to the need for a broader view of built environment modelling and recognition by the infrastructure sector of the value of BIM technology to improve efficiency, quality and cost of project delivery as well as improved asset management.

The Open Geospatial Consortium (OGC) is a global standards organisation, serving the spatial sector by developing publicly-available standards for the delivery and management of spatial data across the Internet. Of particular note is the CityGML[14] standard for delivering city-scale 3D models through the Web, and the more recent extension known as IndoorGML[15] that supports way-finding and emergency egress in buildings. Currently, OGC is developing a new standard known as InfraGML[16] that is seen as possible replacement for LandXML (currently used in Australia for electronic submissions of the cadastre under the ePlan initiative) and designed specifically to address the modelling of broader infrastructure elements of the environment. OGC are also engaging in a broader discussion on the requirements of a digital framework for Smart Cities.

It is clear that both these industry standards bodies are beginning to expand into the other's domain in various ways, again demonstrating the convergence of thinking in both sectors. This has been recognised in a recent landmark MOU, where buildingSMART International and OGC agreed to work together in the development of data exchange standards that are of mutual interest. This marks a significant first step in bringing together these two domains and demonstrates both the need and the opportunity for Australia.

As that work proceeds, we must contribute to ensure that what is agreed in the international arena is appropriate for use in Australia, but more importantly, there is an opportunity for Australia to take leadership in this work as it builds capacity in the formation of the DBE.

Within the Australian context, there are many examples of standards and guidelines across both industry sectors. A couple of examples are provided from the land surveying domain. State jurisdictions have established standards for the electronic lodgement of survey plans and subdivisions: EARL[17] in Queensland (through the DRNM); SPEAR[18] in Victoria; SIX[19] in NSW; Landgate[20] in Western Australia, etc. Similarly, Local Government jurisdictions have established requirements for the lodgement of project data following the construction of assets: ADAC[21] is used mainly in Queensland and covers roads, drainage, open space, water, sewerage and cadastre; the A-SPEC standardised approach covers roads, drainage, open space, water, sewerage and buildings[22] and is used across many jurisdictions in Australia (mainly Victoria and Western Australia), as well as Wellington in New Zealand.

These have been adopted at different times and address very specific data delivery processes as part of established practices, demonstrating the great need for standards. Without undermining those

---

[14] http://www.opengeospatial.org/standards/citygml (accessed 17/07/15)
[15] http://www.opengeospatial.org/standards/indoorgml (accessed 17/07/15)
[16] http://www.opengeospatial.org/projects/groups/landinfraswg (accessed 17/07/15)
[17] https://www.business.qld.gov.au/industry/titles-property-construction/surveying/earl-services (accessed 11/07/15)
[18] https://www.spear.land.vic.gov.au/spear/ (accessed 16/07/15)
[19] https://six.nsw.gov.au/wps/portal/ (accessed 16/07/15)
[20] http://www0.landgate.wa.gov.au/ (accessed 16/07/15)
[21] http://engicom.com.au/adac (accessed 11/07/15)
[22] http://www.a-specstandards.com.au/home.cgi (accessed 11/07/15)

processes, there is a long-term need to rationalise and, where appropriate, amalgamate standards across the construction and spatial sectors in Australia, and across jurisdictional boundaries.

As noted above, as well as information exchange standards, there will be a need to establish robust, legally-enforceable mechanisms to manage access rights to the information held in the DBE. Over the past few years, there has been much discussion around the Virtual Australia and New Zealand initiative (VANZi)[23], initially supported by the CRC for Spatial Innovation and promoted through National Conferences in 2013 and 2014 (the second, in collaboration with buildingSMART Australasia). The two core concepts proposed in this initiative are that access rights to information held in the DBE should align with legal property ownership rights in the real world and that access should be brokered through a network of "data banks" (analogous to financial banks) where people can securely lodge built environment information and gain access to information regulated by those access privileges. These ideas are fully-documented on the VANZ web site.

This brief section has highlighted the need for consistent standards and rigorous protocols as a foundation for the evolution of the DBE. In the next section, we review the nature and scope of the two information modelling approaches that remain non-integrated, but must now be brought together.

---

[23] http://www.vanzi.com.au/ (accessed 11/07/15)

Current Non-Integrated Technology Approaches

This section reviews in greater detail the construction and spatial approaches to supporting the DBE that are the focus of this paper. Both may be seen as ways of managing access to the vast amount of data either created or captured in relation to the physical built environment by structuring it in the form of federated information models.

The section is divided into two parts:

- the first deals with **construction information**, how it is represented using current technologies and the recognised benefits for the construction sector;
- the second deals with **spatial information**, and the range of technologies and standards that have developed to yield applications and benefits for the spatial sector industries.

Construction Information

Construction information is managed using the approach referred to as BIM, standing for Building Information Modelling when referring to the process, and Building Information Model when referring to the entity being modelled[24,25]. BIM supports the management of construction works throughout their full life cycle: one way of comprehending that is to consider a design brief (or program) as a BIM that defines the requirements for a construction project and, as design and construction proceeds (see Figure 4), the BIM represents the realisation of the construction works and finally, during the use
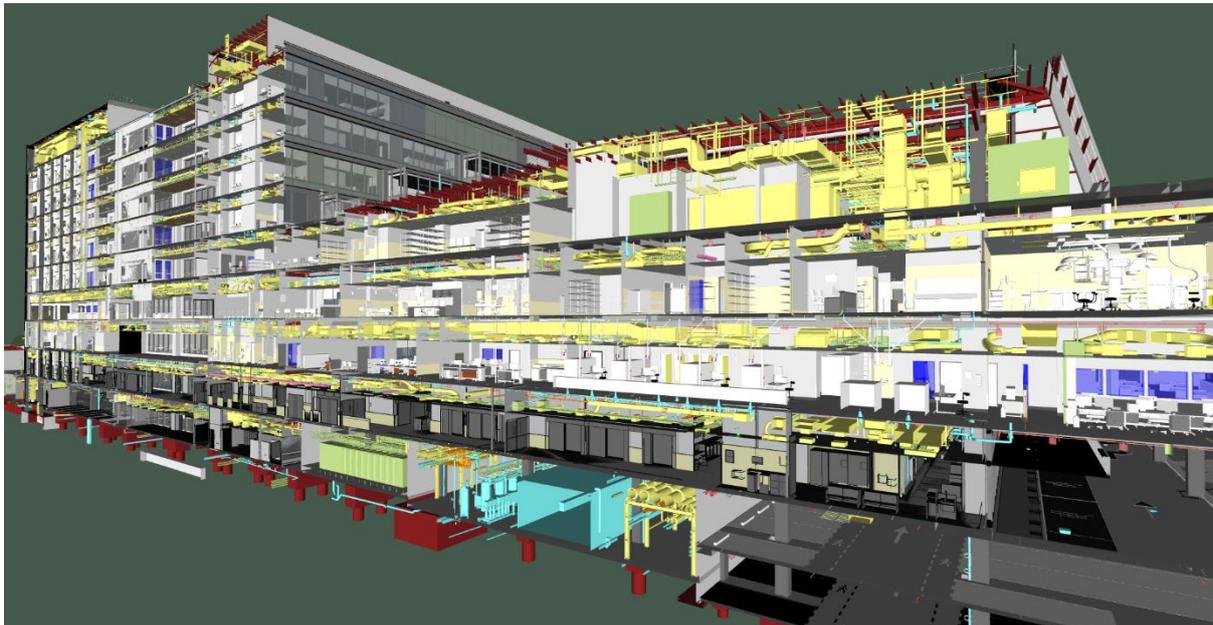
Figure 4 Royal Adelaide Hospital – Construction BIM (image provided by the Hansen Yuncken & Leighton Contractors Joint Venture)

---

[24] An excellent introduction to BIM may be found in: Nick Nisbit & Betzy Dinesen, *Constructing the business case: building information modelling*, British Standards Institution, 2010.

[25] A review of BIM in Australia and New Zealand: McGraw Hill Construction, The Business Value of BIM in Australia and New Zealand: How Building Information Modeling is Transforming the Design and Construction Industry, SmartMarket Report, 2014.

phase of the facility, the BIM supports its management, refurbishment as required and ultimately its demolition or refit.

BIM in one form or another has been used across industries such as mining, automotive, defence and aerospace since the mid-1990s, ever since 3D CAD has been available to the end user and where life-cycle analysis is critical for product production efficiencies and quality assurance protocols. BIM has since evolved to encompass parametric properties (objects with relational 'intelligence') and to incorporate elements of building codes and regulations.

In spite of the traditional focus on buildings, the term BIM is now widely seen to encompass all built environment entities that are constructed to support or house human activities, including buildings, transport infrastructure, civil infrastructure (bridges, tunnels, etc.), urban space, utility networks (water, sewerage, energy, communications, etc.) and all forms of street furniture and fixtures.

Figure 5 shows a BIM of the Pyrmont Bridge at Darling Harbour on the fringe of the Sydney CBD, modelled to support the on-going maintenance of this historic swing-span structure.
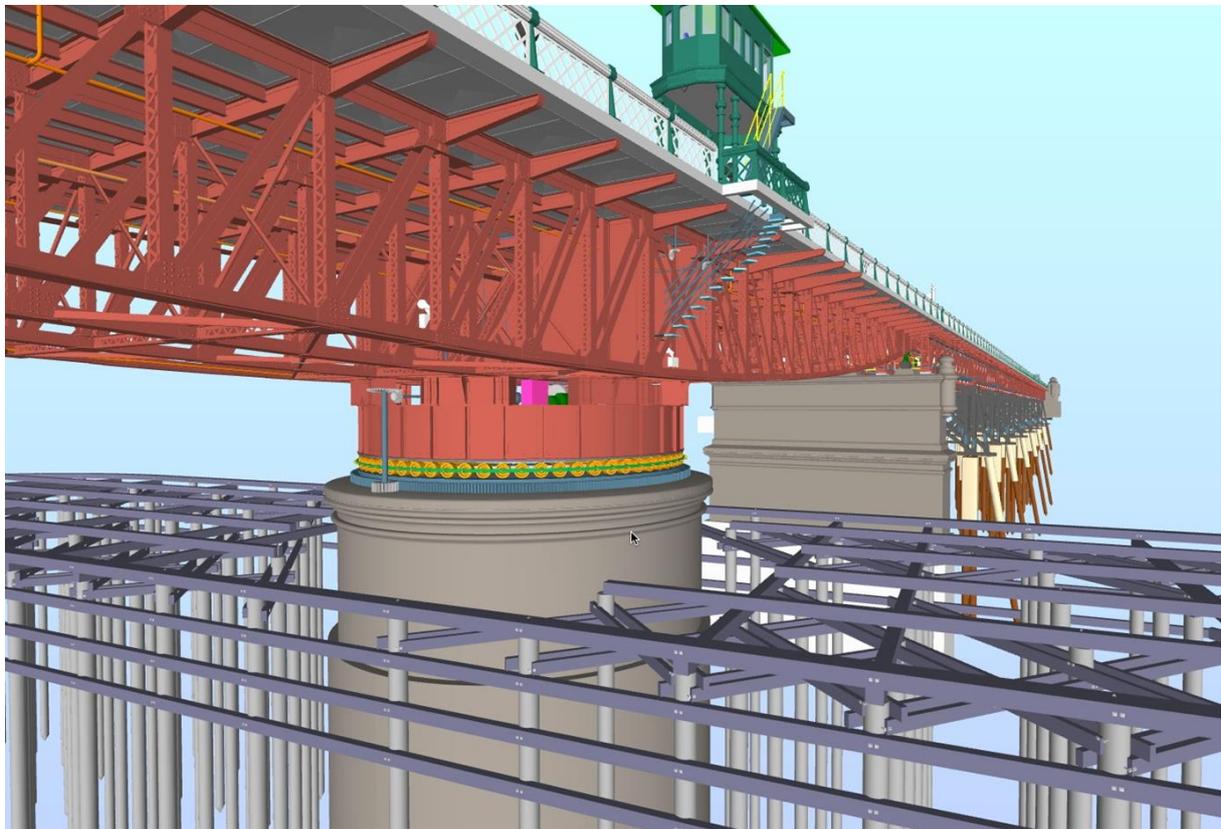
Figure 5 Pyrmont Bridge BIM (courtesy of NSW Sydney Harbour Foreshore Authority, Facilities Department)

The term Virtual Design and Construction (VDC) is sometimes used to cover this broader view, but in this paper, we will continue to use the term BIM because of its familiarity, but its meaning is always to be understood to include all entities that make up the built environment.

In research currently being undertaken at UNSW Australia, and funded by the CRC for Low Carbon Living, the term PIM (precinct information modelling) has been adopted when dealing with regions, typically within an urban context, that must be considered as a collective development (greenfield,

brownfield and greyfield) to address carbon management[26]. This project builds on the concept of BIM, but investigates how it can be expanded to create effective links to spatial data. A PIM would typically provide a far greater granularity of data than is currently offered by most city modelling efforts, some of which contain spatially accurate building envelope representations, whilst others can additionally contain a wide variety of information. The term PIM is starting to be used more widely, but it demonstrates the shift of focus by some BIM practitioners and researchers towards a broader application of BIM technology to encompass a larger urban region.

This expansion of the scope of BIM modelling applications reflects the BIM maturity levels discussed previously with respect to Figure 1. It is also important to note the expanded dimensionality of BIM depicted in that Figure: as BIM has matured, its application in different analysis scenarios has evolved. These are popularly described as 4D (project scheduling), 5D (project estimation) all the way up to nD (providing a placeholder for applications not yet conceived). A full explanation of these dimensions is provided in Appendix A as it highlights the breadth of opportunities for analytics once the BIM approach is adopted.

For many years now prefabrication has been seen as integral to greater efficiency in building construction. Earlier manual 2D CAD systems relied on a product of specified fixed characteristics, mass produced to reduce unit cost; however, this approach never satisfied design flexibility or innovation of product. Meanwhile, in advanced manufacturing sectors such as automotive and aerospace, techniques for mass production and robotic procedures have had a revolutionary impact, and now, with the advent of BIM, that revolution is extending into building and construction.

Construction modelling technology (BIM) is based on 3D object-relational concepts and directed towards capturing the way things fit together three-dimensionally within a broader built environment context, specifically in relation to the operational, design, analysis and management processes that must be supported throughout the life cycle of the constructed facility. This principle applies at all scales, from the component parts of a building (often manufactured and brought to site), through the way those parts are assembled or formed on site during the construction process, to a broader view of how a structure relates or connects to other facilities in its immediate context, or in its broader urban or rural context.

Since these constructed facilities are intended to support human activities, a BIM goes beyond just describing the physical components that make it up. Perhaps more important from an information management perspective are the spatial relationships that are captured in a BIM. This includes explicit definitions of the nature of spaces at appropriate levels of aggregation (e.g. site, building, storey and the internal spaces within a storey), identifying the function or ownership of those spaces and how they relate to other spaces. Spaces can also be collected together in various ways to form zones, often quite independently from the strict spatial hierarchy of the physical object. For example, a commercial organisation may lease a set of non-contiguous spaces spanning several storeys of a building, or a set of spaces may be defined as a fire zone or air conditioning zone within a building in order to support a particular type of analysis.

This ability to group non-contiguous spaces provides a useful method of defining strata titles, one of the major challenges facing the spatial sector. These spatial concepts are critical to understanding the

---

[26] Newton P., et al. *Performance Assessment of Urban Precinct Design - A Scoping Study, CRC for Low Carbon Living*, August 2013. Available online (accessed 17/06/15):
http://www.lowcarbonlivingcrc.com.au/resources/crc-publications/reports/performance-assessment-urban-precinct-design-scoping-study

complexity of the built environment, particularly in relation to the way it is used. It is also important to note that when BIM is applied to transport infrastructure projects, the spatial concepts can be adapted accordingly: the spatial components of a road network will be quite different, dealing with things like road segments, intersections and traffic lanes (for vehicles, pedestrians, cyclists, etc.). These space allocations on a road provide an important mechanism for holding usage information and management responsibility over parts of a road network.

There are two other important concepts that must be captured in a BIM. As noted previously, the built environment is designed for people, so modelling the types of people by their role and their associations within organisations is very important. This includes not only people responsible for all aspects of the design and delivery of construction works (to hold information about how the facility is delivered or managed), but also information about users (owners, occupiers, regulatory authorities who have oversight, etc.).

The other aspect that must be modelled are systems, being any interconnected set of components that collectively deliver or support some service. This covers all types of building or infrastructure services (covering energy, communications, water, waste, air handling, etc.), but could also be used to represent circulation routes, escape paths or any kind of transportation network where required.

Up to this point, the description has focussed on how information is structured to form an information model or 3D digital prototype, but as noted in the opening paragraph of this section, BIM is also a process. That process revolves around support for multidisciplinary collaboration at all life cycle stages of a project through a shared project model.

It is useful, therefore, to characterise BIMs in two broad ways: those linked to specific life cycle stages, viz. briefing, design, construction, facility management and retrofit; and those that have specific disciplinary focus, viz. client brief, architectural design, engineering design (across many disciplines), construction management, as-built for facility managers, etc. These are collectively referred to as *model views*, each being a view of the same construction entity (whether proposed, existing or a historical memory) but from a different perspective.

These model views differ in terms of level of detail, so that as a construction project proceeds the amount of detail specified within the BIM generally increases, typically up to the point where the facility is handed over for occupation. At that point, much of the construction detail becomes less important to the facility manager and can be archived for future use later in the life of the facility to support maintenance repair, re-fit or adaptive re-use projects.

Some have argued that "level of detail" is a misnomer and propose "level of development" as a better term to capture the richness of this concept. This is because objects represented in a BIM may also physically change to support different disciplinary views during the development of a project. Perhaps the clearest example of that case is a concrete slab object: it is clearly viewed very differently by architects and engineers from a functional and design perspective, but when it comes to construction, a builder must break it down into concrete pour segments (each a separate object) to facilitate construction scheduling; one object becomes several in a different disciplinary view.

Another issue that flows from BIM when viewed as a process is how to store the BIM information. In current practice, BIMs are generally passed around as files (Level 2 BIM), but as the models become larger, there is a shift towards the use of model servers where the data is held as an object-oriented database, supporting object level queries, versioning and other traditional database management methods. As the scope of BIM expands to encompass other elements of the built environment, the use of databases becomes more important (Level 3 BIM). However, the implication of BIM model

servers links to another key process concept: collaborative practices to improve the quality of design outcomes.

Though it is technically feasible to hold a multidisciplinary BIM in a single integrated database, there is a widespread view that disciplinary models should be held separately (to support discipline-specific analysis and processing) and only merged together into a single model when a coordination process requires that, e.g. clash detection. The UK Level 3 BIM strategy identifies this as a key opportunity and aims to render this integration more robust through "data-enabled collaborative working based on transactional contracts"[27].

The ability of a BIM to hold information from diverse disciplines in a form that can be effectively shared has led to a collaborative contracting construction delivery process, often called integrated project delivery (IPD). Formal IPD (and other collaborative contracting approaches, such as ConcensusDocs and Integrated Forms of Agreement) create the legal framework to assemble a full project team at the early stages of a construction project so that all might contribute to the design decision-making and cooperatively share BIMs as they are refined through the project life-cycle. Under this contractual model, risks are shared (including both financial risks and profits) in order to minimise conflicts. In that way, discrepancies in the decisions taken are identified before they affect the construction processes on site, where solutions are inevitably expensive and lead to litigation and cost overruns. This contrasts with the traditional construction process where each participant endeavours to shed risk down the supply chain, with far greater risks of litigious outcomes when things go wrong.

The final significant component of BIM technology to be discussed here is the availability of building product data, commonly accessed in object libraries connected to the BIM. Since constructed facilities often include many standard components, a BIM will typically include many instances of objects that are linked to (i.e. reference) external object libraries, allowing much property data (including metadata) to be held outside the main model. This is a critical aspect of BIM that is not currently well managed across the construction sectors in most countries.

The development of national BIM libraries is receiving increased attention in different parts of the world, but it requires strong collaborative agreements to establish a framework for how the data might be stored in the first instance, before product manufacturers are then able to see a business case for providing their product data in BIM format. A key issue here is the establishment of agreed definitions and classification of concepts, products and properties and as construction becomes a more global industry, those definitions need to be internationally consistent. That poses a significant challenge for the construction sector, and is not one that can be easily driven without government support.

One final observation for this section: BIMs traditionally assume a 'flat earth' model as earth curvature is not significant over short distances (typically 800-1000 metres, hence the Google Earth tile spacing). This 'flat earth' approach is changing as large scale linear infrastructure projects, such as roads and railways, adopt a full BIM approach in which terrain (the shape of the earth) and geodesy (accurate geospatial positioning) become critical.

Application and Benefits of BIM for the Construction Sector

BIM allows virtual prototyping of a designed facility or infrastructure project, providing an opportunity to use software tools to assess design performance, extract accurate quantities for costing, test

---

[27] Op. Cit. Department for Business, Innovation & Skills (UK), 2015, p.24.

alternate construction strategies, refine and clarify construction processes including workplace safety measures and site logistics, and provide a coordinating tool for asset management.

One of the specific applications of this virtual prototyping approach is visualisation. During the past decade, several new technologies have been adopted within the construction sector, providing ever-increasing realism along with immersive, real-time, interactive navigation capability. These include virtual reality systems, ranging from individual goggles to large-scale immersive cinemas, augmented reality devices that permit a merging of digital information with our perception of the real world and re-purposed gaming technologies that support real-time navigation and interaction with highly realistic and animated digital models. All these technologies, combined with BIM, provide very powerful tools to help clients and end-users to understand proposed interventions in the built environment.

The advent of BIM has also produced a reliable method to prototype 3D objects and automate the manufacturing processes, particularly in HVAC system disciplines and related supply chains. Its advantages are a relaxation of constrained product design, leading to better performing buildings enabled by optimised products with significant off-site industrialised pre-assembly and prefabrication systems. BIM and prefabrication combine to improve design solutions, bring greater consistency in building and manufacturing processes, reduce on-site errors, enhance a smarter and quicker facility development process, employ a more skilled workforce and add to increased safety.

As noted in the last section, BIM technology also provides a sound basis for collaborative design practices, allowing all members of the design and construction team to have early access to highly accurate information and the opportunity to participate in design planning at an earlier stage. This extends into the construction phase where increasingly, that collaboration is supported using the kinds of visualisation technologies just described. For example, projects may use a purpose built CAVE (Computer Aided Virtual Environment), also referred to as a Decision Theatre, where data models are loaded onto large screens, usually rear-projected, so planning and review meetings can interact with the data and people can stand and point to elements in the model without their shadow falling across the screen.

Apart from those process opportunities, there are many economic benefits of BIM that are well-documented. A report prepared in 2012 by buildingSMART Australasia for the Department of Industry, Innovation, Science, Research and Tertiary Education, recommended 6 national initiatives that were seen by a broad spectrum of industry as required to accelerate the adoption of BIM in Australia. These were supported through wide consultation with 160 industry stakeholders across the construction sector in Australia. That report summarises the key benefits of BIM as follows[28]

> *The key initiatives discussed above if actioned and delivered upon in a timely manner will deliver the following key sector benefits including, but not limited to:*

> - *Industry collaboration and information sharing;*
> - *Productivity gains – time and cost;*
> - *Improved project quality;*

---

[28] buildingSMART Australasia, National Building Information Modelling Initiative. Vol.1, Strategy: A strategy for the focussed adoption of building information modelling and related digital technologies and processes for the Australian built environment sector, report to the Department of Industry, Innovation, Science, Research and Tertiary Education, Sydney, June 2012, p.21. Available on-line (accessed 11/07/15): http://buildingsmart.org.au/wp-content/uploads/2014/03/NationalBIMIniativeReport_6June2012.pdf

- *Transparency and accountability in decision making across whole of project lifecycle;*
- *Increased sustainability; and*
- *Labour market improvements – including safety.*

Appendix C to that report lists the specific advantages identified by the stakeholder group for each of the 6 initiatives[29].

Richard Saxon, a respected BIM researcher and consultant in the UK, identifies both 'pull' and 'push' factors where BIM drives economic growth[30].

The pull factors include the desire:

- *To reform the construction industry into a customer-focussed one, delivering outcomes not simply outputs and at substantially lower cost;*
- *To respond to returning demand with less inflationary pressure.*
- *To achieve sustainability in the built environment; more economical, environmentally sound and socially positive.*
- *To develop 'Digital Built Britain,' the concept of a data-driven asset base.*

The push factors where BIM promotes growth include:

- *reduced cost, risk and time in design, construction and operation of buildings, based on the creation of a 'Single Source of Truth' for all parties;*
- *potential for higher whole-life value from comparable investment;*
- *expanded services to clients to raise the quality of their outcomes;*
- *enhanced international competitiveness, with reduced importing;*
- *offsite construction for economy, speed and safety reasons;*
- *emergence of the ICT sector service as part of construction.*

In the UK, the process innovations facilitated by BIM are expected to yield significant benefits in four areas, with early indications that these are realistic: reduced cost leading to improved productivity; faster delivery, coupled with improved quality; lower greenhouse emissions through streamlined processes and improved design; and exportable expertise. The UK Government Construction Strategy has established the following industry goals for 2025[31]:

By working in partnership, the construction industry and Government jointly aspire to achieve by 2025:

1. *A **33% reduction** in both the initial cost of construction and the whole life cost of assets [Based on 2009/2010 benchmarks in line with the Government Construction Strategy]*
2. *A **50% reduction** in the overall time from inception to completion for new build and refurbished assets [Based on the industry's performance in 2013]*
3. *A **50% reduction** in greenhouse gas emissions in the built environment [Versus a 1990 baseline. This is set out in the Green Construction Board's Low Carbon Routemap for the Built Environment]*

---

[29] Ibid, pp. 42-57.
[30] Richard G Saxon: *Growth through BIM*, Research Report for the Department for Business, Innovation and Skills, Construction Industry Council, 25 April 2013, pp. 9-10. Available on-line (accessed 11/07/15): http://cic.org.uk/news/article.php?s=2013-04-25-cic-publish-growth-through-bim-by-richard-g-saxon-cbe
[31] Op. cit. Department for Business, Innovation & Skills, 2013. p. 19.

4. A **50% reduction** in the trade gap between total exports and total imports for construction products and materials [*The UK imports £12 billion of construction products annually and exports £6 billion. ONS monthly statistics of building materials and components: February 2013*]

These are long-term ambitions shared by industry and Government jointly. The Construction Leadership Council will develop an action plan to achieve these ambitions between now and 2025.

The trials in six UK Government Departments of 2013-14 have already demonstrated 20% cost reductions, well before the April 2016 mandate of BIM Level 2 for all Government procurement[32]. Those savings from the UK 2011 Construction Strategy (primarily from BIM) amounted to at least £840M but may have been as much as £1.2Bn[33] in what was effectively the first full year of trials.

Spatial Information

Spatial Information describes the physical location and attributes of all things around us – information fundamental to the lives of everyone. Historically, it is based on technology generally referred to as GIS (Geographic Information System), finding its roots in 2D digital mapping, then evolving to 2.5D (aerial images draped over terrain surfaces and extruded polygons to represent objects in the landscape), and today incorporates rich 3D information including surface terrain and 3D modelled features, often with high fidelity image mappings to enhance visual realism. Spatial scanning technologies are adding new representations, including point clouds and rendered 3D real-time animated models. The application of gaming technologies has led to visually-compelling, animated 3D urban environments that can be navigated by end-users in real time, providing a powerful platform for both professional planning, community engagement in the planning process and smart navigation tools for way-finding and asset management.

The focus of spatial modelling is on features that are located on, below or above the surface of the earth (Figure 6, over page). Entities in a spatial model are geospatially located using geodetic coordinate systems, with complex 3D spherical measurements so that they are accurately located within the physical environment. Features in a spatial model may be very diverse, representing a wide range of physical phenomena. In an urban modelling context, these include buildings and other structures, transport infrastructure, landscape features, subterranean formations (e.g. geology, pilings, pipes and tunnels), street furniture, road signs or any feature of the built environment that may be of interest in a disciplinary computational process.

Though features may have a complex 3D representation (to support visualisation or discipline-specific analytics), they are anchored to relatively simple geometric constructs including nodes, lines (or curves), polygons or bounded volumetric regions. This leads to the notion that geospatial features can be broadly categorised as geo-located entities, linear features or polygonal regions, each offering general classes of analytics. For example: geo-location is commonly used to determine topological relationships (nearest feature type, such as an bank or school, to any given location); linear features form networks that are routinely used in way-finding and crowd management; and polygonal features are used to identify regions with a common characteristic, leading to classic methods of correlating

---

[32] Ibid, p.60.

[33] Antony Oliver: *The Road to 2016 BIM Compliance – How is the UK Shaping Up?* Interview with Mark Bew, Chair of Government BIM Task Force, in Infrastructure Intelligence, 03 Jun 2015. Available on-line (accessed 11/6/15):
http://www.infrastructure-intelligence.com/article/jun-2015/road-2016-bim-compliance-–-how-uk-shaping

overlapping regions with differing characteristics to understand complex geographic relationships (e.g. correlating ethnicity with home ownership across an urban region).

This capacity to perform a variety of increasingly complex analytics based on relatively simple geometry with consistent attributes has led to the development of a specific class of software tools known as Spatial Decision Support Systems (SDSS). These are now widely used to inform urban and regional planning and urban research, and have become a key tool in understanding the impact of alternative scenarios when addressing regional planning issues.

A specific challenge in spatial modelling is defining the precise positioning of geographic features, leading to an entire discipline concerned with defining map projections, height datum standards and geodetic modelling.

Implicit in the above discussion is another key characteristic of spatial modelling: the ability to associate property data with each feature, not only geometry and visualisation properties, but any attribute/value pair required for discipline-based analysis procedures. There is also the ability to associate metadata with spatial features, providing a way of declaring the provenance (reliability, relevance or accuracy) of features and attributes in a spatial model.

A critical extension (or outcome) of the use of metadata/attribute data is the opportunity for any spatial feature to link to data held in remote databases. This has meant that the spatial industries have become the de facto custodians of big data, providing the essential technologies that allow governments, large organisations and research institutes to manage access to the vast amount of data that is now collected and held by many institutions, including real-time monitoring data. Putting aside, for the moment, all the legal and privacy issues around access to big data, this role has become one of the critical responsibilities of the spatial sector and is key to many of the issues that are raised in this paper.

The challenge of creating and managing these links to big data has led to a number of innovations, particularly drawing on techniques associated with artificial intelligence (AI), the semantic web and the use of ontology databases. This has led to the ability to process very complex spatial queries that rely on the geo-location of a spatial feature and then use AI reasoning algorithms that first identify suitable data sources that provide information related to the query and then retrieve that data as a response to the query. The potential opportunities afforded by this technology are very significant.

Figure 6 The scope of spatial modelling

As these spatial technologies for holding and processing information continue to evolve, so too are technologies for collecting spatial data. These now include techniques such as aerial (including Unmanned Aerial Vehicles - UAVs) and satellite imagery (both multi-spectral and stereoscopic imagery), the Global Navigation Satellite Systems (GNSS), LiDAR and other scanning systems, and a whole plethora of environmental sensor technologies.

Developments in satellite imagery—starting with the USA spy satellite programs of the 1960s and beyond, through the SPOT program used by Google and others, up to 2015's WorldView 3 initiative—have provided both governments and the public with ever-increasing awareness of the earth and their own spatial contexts, most often in an easily comprehendible visual form. Together with global navigation satellite systems capable of 1cm accuracy (European Galileo) in the next few years, imaging satellites and Digital Terrain Models will provide an ever-more accurate spatial understanding of the earth's surface.

At the same time, we see an ever-expanding range of related technologies and applications that draw on spatial information to provide specific benefits. This includes, but is not limited to: precision agriculture, virtual reality, augmented reality, intelligent transport, driverless cars, big data analytics, geo-browsers (such as Google Earth), digital globe and Australia's National Map web portal. The application of gaming technologies has led to visually-compelling, animated 3D urban environments that can be navigated by end-users in real time, providing a powerful platform for both professional planning and community engagement in the planning process.

The recent National Map[34] initiative (Figure 7 & Figure 8) of the Commonwealth Government, and the Queensland and NSW Globe initiatives, are aligned to both Federal and State Government open data initiatives and a vision popularly referred to as Digital Earth. Digital Earth can be considered as an

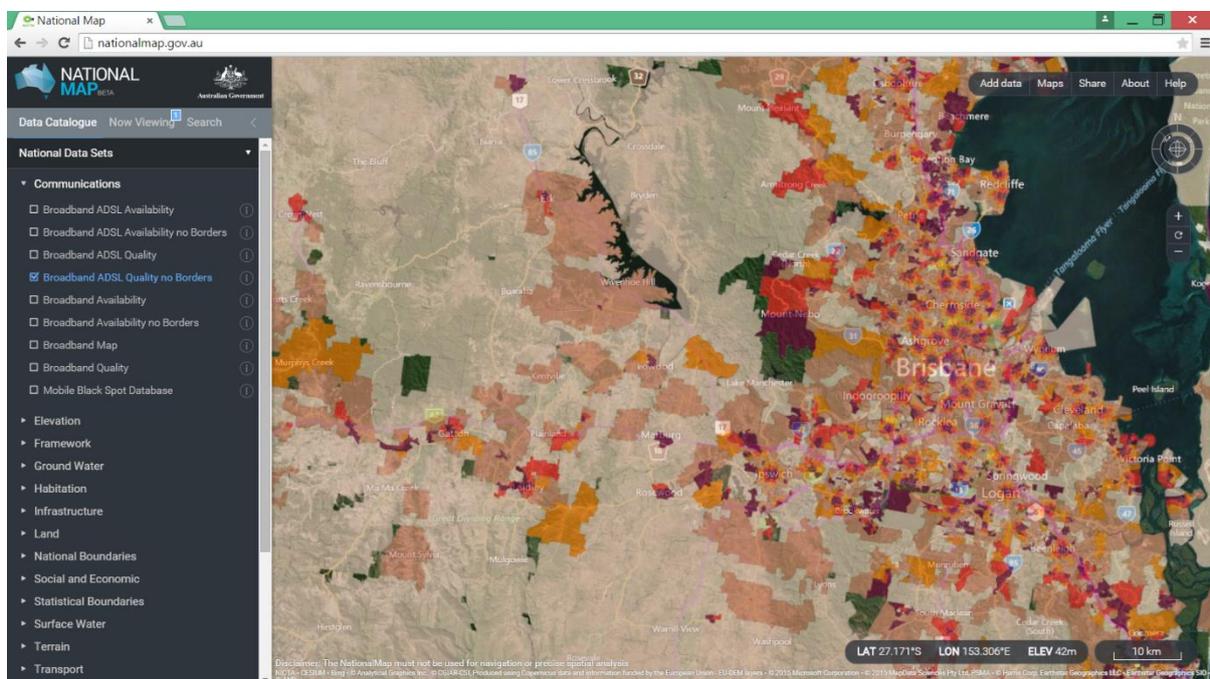*Figure 7 The availability and quality of broadband access can be followed through the open data being published to the National Map. Broadband is an example of one service that integrates with the built structure. Broadband is also a key enabler of the' internet of things' and the real time integration of environmental and building sensors with the BIM.*

---

[34] National Map: http://nationalmap.gov.au/

Figure 8 National Map currently supports multi-dimensional spatio-temporal modelling (time and space) so has potential to be enhanced to facilitate a 'BIM Globe' to enable publishing of BIM models in a digital earth metaphor.

integral part of other spatial technologies including: earth observation, geo-information systems, global positioning systems, communication networks, sensor webs, electromagnetic identifiers, virtual reality, grid computation, etc. It is seen as a global strategic contributor to scientific and technological developments, and will be a catalyst in finding solutions to international scientific and societal issues where location is retained as a common index for information.

Applications and Benefits for the Spatial Industry

"The current value of the spatial industry in Australia is estimated to be $18 billion, and globally valued at $250 billion. By the end of this decade the industry is expected to be a trillion dollar industry"[35]. It provides competitiveness and productivity to our mining, building and agricultural industries, and facilitates the stewardship of our important environmental assets, such as the Great Barrier Reef. The spatial industry plays a very important role in several key areas: water security, food security, management of epidemics, climate change, extreme weather, disaster management all rely upon the services and technologies of the spatial industry for vital decision support.

The traditional role of the spatial industry has been the management of land ownership and title, enacted through the discipline of land surveying. This has traditionally been based on paper drawings held in State and Commonwealth land registry repositories, but there is a program underway to move towards digital technologies for both 2D and 3D cadastre[36]. An ePlan working group has been established under the auspices of the Intergovernmental Committee on Surveying and Mapping (ICSM), charged with "introducing a digital protocol for the transfer of cadastral data between the Surveying Industry and Government"[37]. The work to date has focussed on 2D cadastral information in

---

[35] Opening Remarks by Cr. Graham Quirk, Lord Mayor of Brisbane, at the Pivotal 2015 launch, Brisbane, 22 April 2015.

[36] ICSM: Cadastre 2034: Cadastral Reform and Innovation for Australia - A National Strategy, Geospatial Frameworks Pty Ltd, Darlington, WA, March 2015.

[37] ICSM web site: http://www.icsm.gov.au/eplan/ (accessed 14 June 15)

LandXML format, but a recently established working group involving key stakeholders and research institutions is looking at 3D cadastral data, with a particular focus on the emerging InfraGML standard and IFC.

From that starting point, spatial modelling technologies and techniques have expanded dramatically to demonstrate value across a wide range of disciplinary domains. These can be broadly categorised into 7 areas of application:

1. Planning and logistics at a regional scale (commonly referred to as GeoDesign), including land use, transport infrastructure, urban planning and research, etc.;
2. Operation and management of local government assets, utilities, transport networks, civil infrastructure, etc.;
3. Predictive modelling, including urban climatology, carbon impacts, demand forecasting, etc.;
4. Access to open data, using both urban feature property links and geocoded links;
5. Capturing and visualising urban form, using technologies ranging from satellite imagery, aerial photogrammetry and LIDAR scanning techniques and more recently, Serious Gaming;
6. Social utilisation for navigation and for commerce;
7. Situational intelligence, e.g. intra-Government briefings and crisis/emergency management;

A joint publication by the Surveying & Spatial Sciences Institute (SSSI) and Esri Australia in 2013[38] highlights the many ways in which GIS contributes to Local Government in Australia based on a survey and several local and international case studies. A core conclusion drawn from the study states, "Judging from the Study's findings, it's clear the new frontier for Australia's local governments is integration – whether that's integrating GIS with core business systems; integrating departmental data silos; or integrating data across all levels of government"[39]. It is important to note that there is no mention in that report of integrating with construction data (or BIM), even though local government have a key responsibility in assessing developments for compliance.

A group of international geographic and environmental scientists from government, industry, and academia, brought together by the International Society of Digital Earth, recently published a position paper entitled, "Next-Generation Digital Earth"[40]. The working group suggests eight key applications of the Digital Earth:

1. *Not one Digital Earth, but multiple connected globes/infrastructures addressing the needs of different audiences: citizens, communities, policymakers, scientists, educationalists;*
2. *Problem oriented: e.g. environment, health, societal benefit areas, and transparent on the impacts of technologies on the environment;*
3. *Allowing search through time and space to find similar/analogue situations with real time data from both sensors and humans (different from what existing GIS can do, and different from adding analytical functions to a virtual globe);*
4. *Asking questions about change, identification of anomalies in space in both human and environmental domains (flag things that are not consistent with their surroundings in real time);*

---

[38] Alicia Kouparitsas (Ed), *GIS in Local Government Benchmark Study*, Joint Publication: Surveying & Spatial Sciences Institute (SSSI) and Esri Australia, August 2013.
[39] Ibid, p.7.
[40] Michael F. Goodchild: "Next Generation Digital Earth", in *Proceedings of the National Academy of Sciences*, July 10, 2012. Available On-Line (accessed 11/07/15): http://www.pnas.org/content/109/28/11088.full.pdf

5. *Enabling access to data, information, services, and models as well as scenarios and forecasts: from simple queries to complex analyses across the environmental and social domains.*
6. *Supporting the visualization of abstract concepts and data types (e.g. low income, poor health, and semantics);*
7. *Based on open access, and participation across multiple technological platforms, and media (e.g. text, voice and multi-media);*
8. *Engaging, interactive, exploratory, and a laboratory for learning and for multidisciplinary education and science.*

Australia's recent launch of the National Map as a context for Government to publish open spatial data places us at the forefront of initiatives in Digital Earth domain. This is still under development, but the technology upon which is has been built (Cesium)[41] provides an excellent platform for the DBE. The following examples illustrate that potential. Figure 9 shows the huge potential of this technology to display high quality visual imagery overlayed into the National Map platform.

Figure 9 This application is a 3D model/rendering of the Old Town of Girona, a historical section of Catalonia, Spain. It's a good example of combining data collected from numerous sources and converting them to a unified format for the National Map platform.

The next example (Figure 10) illustrates a combination of six different data sources, in different formats and from different origins, combined to create this single model with three layers of information. This prototype demonstrates the potential for presenting large complex building data through a 'BIM globe' established upon the Government's current National Map platform.
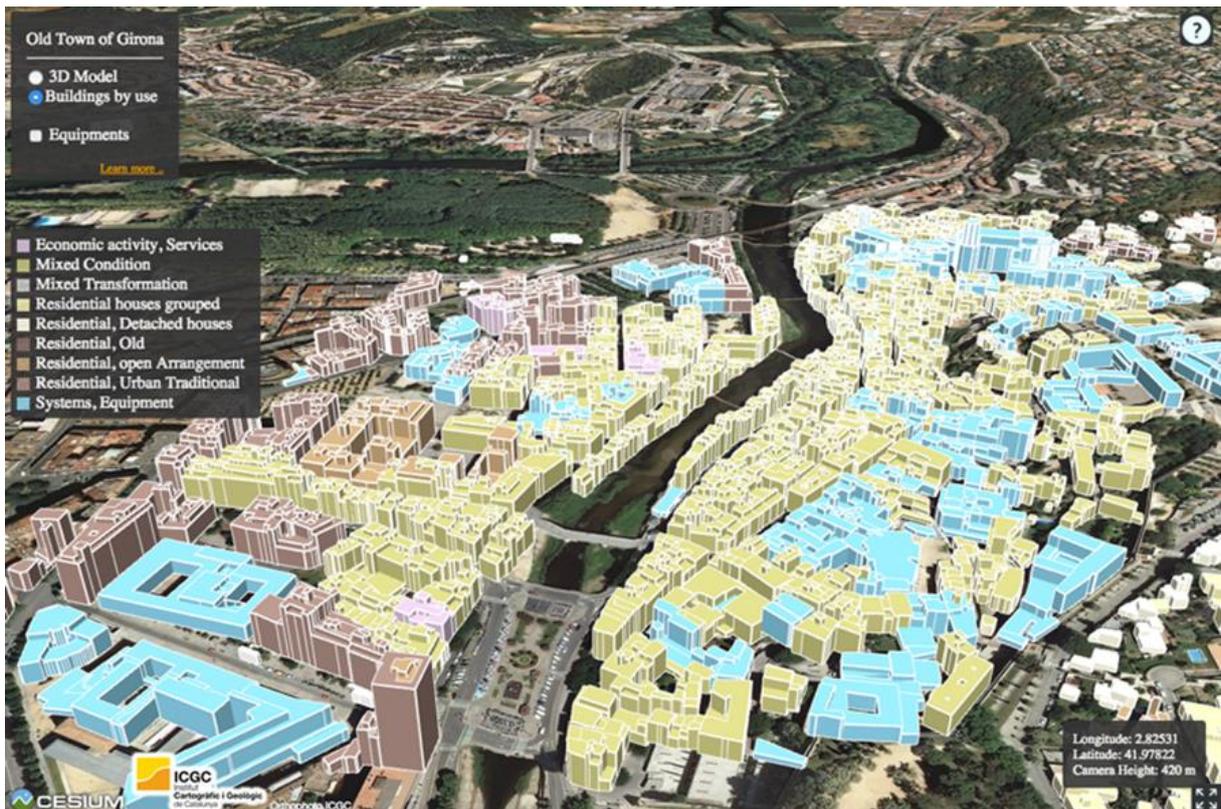
---

[41] http://cesiumjs.org/demos/catalonia-spain.html

Figure 10 Data from diverse sources packaged into a single layered model on the Cesium platform

Integrated Technology Approaches

The previous sections have discussed the rapid growth in the development of information modelling technologies in the two distinct spatial and construction sectors, describing the kinds of benefits that have been identified as flowing from the digital technologies.

Five overriding observations follow from this reflection:

- Both industry sectors have recognised the essential benefits of robust information management protocols to support their underlying goal to better manage the natural and built environment;
- Both adopt the same essential strategy of capturing and holding data about the real world in the form of information models that effectively structure that data to better understand the environment;
- Both sectors have developed and adopted open standards as a means of increasing efficiency through the sharing of information and providing support for streamlined processes;
- Both sectors are looking at ways of extending the reach of these digital technologies; the spatial sector is increasingly interested in capturing the fine detail of geographic features, while the construction sector is actually broadening its reach to address the full gamut of construction works, but more importantly, has recognised the importance of capturing the spatial context of any object;
- Finally, when integrated, both have the in-built capacity to greatly accelerate savings for industry and Government, and create new business opportunities, including exports, for a very small investment.

As a consequence of these developments, there are a growing number of initiatives in different parts of the world to bring these two domains together. Several reports and publications have appeared that discuss the issue. For example, the Fall 2010 issue of JBIM, the Journal of Building Information Modelling in the US was devoted to the theme, with a general focus on the importance of linking BIM to location[42]. A comment piece appeared recently in the web-based newsletter Infrastructure Intelligence, produced by the US Association for Consultancy and Engineering, putting the case for integrating BIM & GIS[43]. Gomez, et al (2014) have implemented a Campus Landscape Information Model[44] that demonstrates an approach to integrating BIM and GIS. A local Australian example that demonstrates that collaboration is key for a project to embark on the path of integrating GIS and BIM[45]. As a final example, a 2-page opinion piece appeared last year in Geospatial World under the title, "The Crossover Revolution" [46].

---

[42] JBIM, Journal of Building Information Modelling, Official publication of the National Institute of Building Sciences, buildingSMART Alliance, US, Fall 2010.

[43] Ian Gilbraith, Digital Infrastructure – the future of engineering, May 2015. Available on-line (accessed 15/06/15): http://www.infrastructure-intelligence.com/article/may-2015/digital-infrastructure-%E2%80%93-future-engineering?utm_medium=email&utm_source=transactional&utm_campaign=weekly-email

[44] Paula Gómez, et al. "Campus Landscape Information Modeling: Intermediate Scale Model that Embeds Information and Multidisciplinary Knowledge for Landscape Planning", p. 61-65 . In: *Proceedings of the XVII Conference of the Iberoamerican Society of Digital Graphics: Knowledge-based Design* [=Blucher Design Proceedings, v.1, n.7]. São Paulo: Blucher, 2014.

[45] Alan Hobson, "Technology, Innovation, and Collaboration in Project Delivery", in *Network: Pathways to Innovation*, A technical journal by Parsons Brinckerhoff employees and colleagues, Issue 76, August 2013, pp.21-23. Available on-line (accessed 11/07/15): http://www.pbworld.com/news/publications.aspx

[46] Bram Mommers, "The Crossover Revolution", *Geospatial World*, March 2014, pp.62-63.

At its plenary meeting in Toulouse in June 2012, the ISO/TC 211 committee (which is broadly responsible for international standards in the spatial sector) established an "Ad hoc group on BIM/GIS" that held an inaugural joint workshop in Seoul on 12 October 2012 to initiate discussions on the relationship of the BIM and GIS sectors. This was attended by members from the two ISO Technical Committees representing spatial (ISO/TC 211) and construction (ISO/TC 59/SC 13), as well as representatives from buildingSMART and OGC. The group met on a number of occasions in subsequent years, having the effect of initiating the dialogue on the issue. However, it now appears to have run its course as a forum for collaboration.

Perhaps as an outcome of that initiative, the OGC and buildingSMART have begun to maintain closer cooperation in the development of standards. A landmark MOU was agreed in April 2014 to work jointly on the development of a standard for representing the complex geometry of alignment for linear infrastructure elements (such as road, rail, pipeline, etc.). The two groups worked together to agree a common conceptual model for alignment, then separately implemented consistent standards following the common concept model: OGC has embedded the alignment in the new InfraGML standard currently under development; while buildingSMART have recently approved the alignment schema as an extension to IFC4.

This leads to the question, where are the essential touch points between these two separate views of the built and natural environments? In the following discussion we identify several areas where spatial and construction information begin to intersect.

The first touch point is asset management: both sectors identify asset management of buildings and infrastructure as one of the strategic applications of digital modelling. For the construction sector, the challenge is how to extract appropriate asset management data from the BIM developed for the construction process in order to support on-going facility management, recognising that significant operational costs can be mitigated throughout the useful life of a facility by quality information. This is directly addressed in the UK Construction 2025 program and BIM initiative; an early exemplar program being the CrossRail program in the UK. An associated challenge that the construction sector is taking on board is how to capture BIM information for the vast quantity of existing building and infrastructure stock. Laser scanning and photogrammetry are two methods for capturing that data, combined with intelligent software to identify construction elements, and final verification by human analysis. From the spatial perspective, asset management is all about good stewardship of both constructed and natural features of the environment. A central goal of almost all spatial information technologies is to achieve better management and custodianship of the world we inhabit.

A second common touch point has been the practice of inserting BIMs into a spatial model of a city or precinct. Such an approach may appear to address the need for integration, but can be limited as it inevitably leads to some loss of information simply because much of the rich semantics of the BIM is stripped out of the model in the process. A more intelligent approach would provide 'spatial reservations' within the city spatial model for BIMs to populate as they become available, providing some interoperability in the near-term, with full integration (by linking to a full BIM held in a BIM server database), as the longer-term aim.

This leads naturally to a third touch point: a long-standing weakness of construction information modelling has been the lack of a rigorous mechanism to contextualise the construction works. It has become common practice within the construction sector to make use of visualisation technologies to illustrate what a proposed development will look like within its urban context. This has moved from the early practice of superimposing a rendered perspective view of a design into a photograph of its context, to the now-common practice of inserting a rendered 3D BIM into a city model (providing the

added benefit of being able to analyse overshadowing and sight lines). The use of Serious Gaming technology takes this to a new level, providing the ability to navigate such city models in real-time.

However, these visualisation approaches only address one aspect of context, failing to take advantage of the deep sources of spatial information that can provide a full contextual understanding of constructed facilities. It should also be noted that many of the elements of a parametric BIM have some degree of embedded intelligence, particularly in terms of interactions with other elements within the model, even to the extent of influencing behaviours. For example, an inserted component such as a fan unit can be automatically sized to deliver the required air flow in an air handling system. This aspect will inevitably be expanded in the future and offer spatial relational interactions beyond the BIM and into the spatial world.

Another touch point is the cadastre. The construction sector relies on accurate cadastral data as the starting pointing for any construction project. Traditionally, that is provided in 2D paper documents (commonly now in digital form) certified by a professional land surveyor, but rarely delivered as 3D data. As discussed previously, the spatial sector has recognised the need for a robust 3D cadastre, but existing spatial modelling technologies are poorly positioned to represent that information, especially when dealing with complex strata titles and aerial or subterranean easements. Increasingly, the spatial industry is starting to look to the construction sector to provide ways of capturing complex 3D cadastral geometry.

Another significant touch point is the importance placed on external data links. In the construction sector, this is focussed on the concept of a product library as an external reference source for detailed information about the components of a facility. This allows a single definition of a product to be held in one place, but referenced to many instances of that component within a single BIM or even across many construction models: one centralised source of truth. At the same time, one of the most significant contributions of the spatial sector has been to take this concept to a whole new level in addressing the issue of big data, and especially the development of spatial queries based on geolocation. Both sectors are also actively investigating ontologies and semantic web technologies to facilitate access to external reference data sources by addressing the ambiguities associated with the terms and concepts used in different disciplines and jurisdictions.

Another touch point is the development application process through which the construction sector engages with planning authorities. As noted previously, local government is a major user of GIS technologies, but have not yet fully appreciated the opportunity to accept building models as part of the DA process. It could become a two-way process: the BIM is submitted for automated compliance-checking and integrated into the local government information repositories, while the existing local government planning tools can provide a contextual analysis of the building during the design stage. Most planning authorities still insist on printed 2D outputs from a full 3D BIM, at significant additional cost (including archive storage costs), time, and with a huge loss of information.

The final touch point is what might be termed the tyranny of scale. The spatial sector traditionally deals with the world at a geographic scale and has developed appropriate abstract modelling constructs to cope with the broad scale of that information (almost a top-down view), while the construction sector is focussed on the elements or components that are assembled to form the built environment (the bottom-up view). To some extent, both approaches have been constrained by the limitation of digital modelling processes and available digital storage capacity. Since those technology limitations are dissolving, the two sectors are starting to converge: the spatial sector is seeking to address increasing levels of detail in its models, while the construction sector is seeing the opportunity to broaden the spatial scope of its models.

This convergence inevitably leads to the development of the DBE concept. As the capacity of digital technologies grow in terms of processing power, reasoning power (through the rapid evolution of artificial intelligence) and storage capacity, the vision of a comprehensive digital representation of the physical world is rapidly becoming realisable. This lies at the heart of the Digital Built Britain strategy (as the name implies), but also lies at the heart of many emerging trends that relate to smart cities. We see a future where digital technologies become more ubiquitous; impacting on every aspect of our interaction with the real world.

The early innovations in this space are already becoming mainstream, making use of personal mobile communication technologies, the ever-expanding wireless network and the availability of real-time data services. The community are already being prepared by the media for the emergence of driverless cars and automated operation of the urban infrastructure to manage the increased densification of our cities.

All these innovations rely on one or both of these information technologies. This suggests the inevitable need to bring them together in order to support a more comprehensive way of representing the DBE. This is illustrated in Figure 11.

The figure shows that the DBE brings together two "healthy" parts to make an "improved" whole. Current spatial enablement with maps and associated alphanumeric data is very successful: users of these systems are quite happy to search a map or alphanumeric data to satisfy queries. The spatial sector is not broken or doing a poor job that needs a DBE to bring a solution. Equally, there are significant design & construct projects where BIMs are handed over to the asset management team on completion and the data becomes part of the asset maintenance system (although BIM is still not
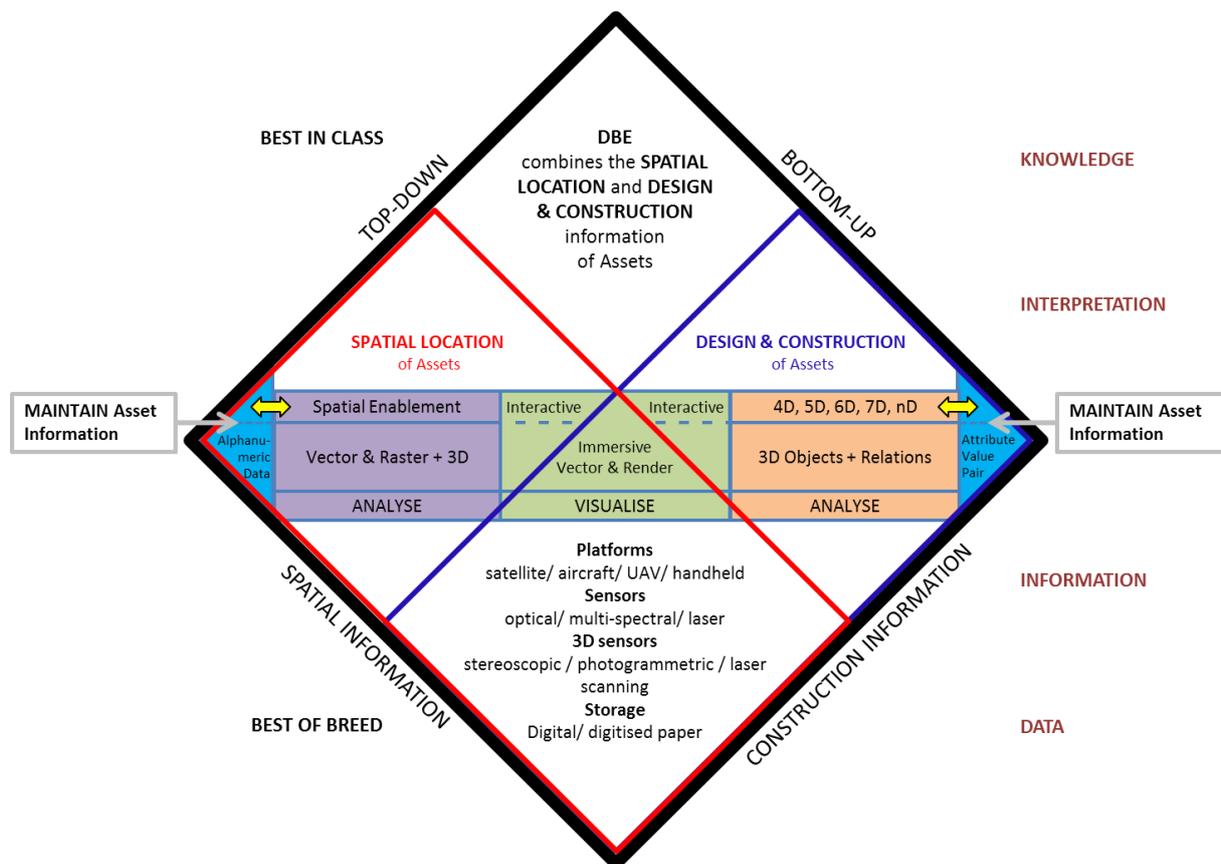

Figure 11 Integration of spatial and construction information to deliver the Digital Built Environment

used on many construction projects, adding significant costs and risks to clients, including Governments). The process of life cycle management of construction information using BIM is fit-for-purpose and achieving maturity: not broken. The integration of spatial and construction information delivers best-in-class solutions based on a greater level of interoperability within the DBE. Put simply, the whole is greater than the sum of the parts.

The figure also shows that the same captured data at the base can be used in either the spatial sector (red box to the left) or the construction sector (blue box on the right). Both geospatial and construction software systems have the ability to visualise the data after it has been analysed, while the technologies that have evolved in the computer gaming industry (at the centre of the diagram) have delivered immersive, real-time environments that bring together information from both sectors to close the visualisation gap, which it does very effectively.

The top half of the diagram brings the two sectors together at the asset management stage. Once integrated, it forms the best-in-class DBE: best-of-breed software is deployed in data capture, planning, design, construction and analysis stages, but then integrated into the DBE to deliver a comprehensive, spatially-located digital record of the built environment. Data collected and created through best-of-breed processes at the base is integrated to create best-in-class knowledge of the physical world.

Finally, the right hand side of the diagram shows the evolution of the process, where data that is structured becomes information, which in turn is analysed to inform correct interpretation, and then when understood, contributes to knowledge and informed decisions.

The resulting DBE provides the best-in-class approach to provide the knowledge required to manage all the complexities of the built environment in a way that addresses the major challenges around rapid global urbanisation and sustainable life styles for a global population.

Opportunities

This paper proposes the need to develop a national data policy that will both encourage and facilitate the integration of the disparate technologies that deal with spatial and construction information. The integration of these technologies will form the basis of the DBE, a new piece of national digital infrastructure that will transform the way we plan, design, construct, manage and interact with the physical built environment.

In developing the argument for that integration in previous sections, we have identified several opportunities that are summarised here.

- The DBE provides a federated platform that links to big data in all its forms, whether through direct links from entities in the DBE to real-time and static databases, or through the use of spatial queries and the semantic web technologies to access contextual and spatial data relevant to any built environment facility, at any scale.
- The DBE provides a framework that binds the Internet of Things, and real-time data collected through sensors and meters, to the information held in the DBE to facilitate our management and interaction with the natural and built environment.
- The links through the DBE to the full spectrum of spatially-linked sources (covering demographic, socioeconomic, environmental, regulatory and institutional data) opens enormous opportunities for the development of new innovative tools, effectively creating new business opportunities and encouraging innovation.

- The DBE will foster new solutions and approaches that will enable Australia to address the accelerating demand for urban living and the international trend towards urbanisation.
- A fully integrated DBE will provide a comprehensive technology base for smart buildings, precincts and cities.
- The DBE will provide improved planning and design processes, supported by better information management, to yield a quality built environment that is more fit-for-purpose.
- Moreover, the DBE will lead to a more sustainable and resilient built environment with corresponding reduction in greenhouse gas emissions and reliance on fossil fuels.
- We can expect increased productivity in the delivery of infrastructure: the catch cry in the UK, based on trials, is "build four and get the fifth one free". The UK target is for even greater savings.
- The Australian workforce that participates at all levels in the spatial and construction sectors will gain new skills and expertise in an emerging area of digital innovation, providing both personal and national knowledge export opportunities, particularly relevant to Australia's position in the Asia Pacific region.
- The DBE has significant implications for the financial sector, providing for example, a more accurate and reliable basis for assessing insurance risks and claims. Similarly, new applications will emerge around business intelligence, real estate, property portfolios, asset management, etc.

Challenges

Like most major digital innovations, the DBE will evolve naturally as a consequence of the opportunities outlined above, but there will be some specific sticking points where deliberate and collaborative action is needed to smooth and accelerate the process. Australia can choose to wait for others to address the challenges and become late adopters of the DBE and subsequent opportunities. Alternatively, we can recognise and address the challenges—industry, Government and academia in partnership—and place Australia and our spatial and construction industry sectors in the driver's seat to reap all the benefits of being early adopters.

The following list summarise the key challenges, most of which were canvassed in earlier sections.

- There is a need for open standards for both information exchange and process management that facilitate the innovation needed to deliver the DBE.
- There is a need to establish the "baseline" data requirements to manage assets through standardisation.
- There is a need for a regulatory mechanism that controls and facilitates access to the information repositories and big data links provided by the DBE, with built-in authorisation mechanisms that respect the need for privacy and security, while streamlining access.
- Without losing the impetus and opportunity for Australia, we must recognise that we are part of a global community. Standards and processes adopted in Australia must align with international initiatives.
- There will be a pervasive need for education to equip stakeholders at all levels in the professional, trade and community spheres as we transition to a built environment that is managed through the DBE.
- The spatial and construction sectors are represented by a very diverse range of disciplines and sub-contractors, generally working in small to medium size enterprises, so there will be a major challenge around change management, endeavouring to transition such a fragmented industry in concert with a rapidly evolving technology. The construction sector, especially, is lagging behind the manufacturing industries in the widespread adoption of digital methods. There is a need to close that gap in order to facilitate the integration being proposed in this paper.

- In a competitive market, large companies will vie for market dominance through technology innovation, becoming early adopters who pioneer new work processes. This can have a positive impact through the development of innovative practices that are eventually adopted across industry, but can also lead to unhealthy market dominance and reliance on proprietary solutions that eventually serve to impede sector-wide innovation.

- Much of the DBE will encompass existing infrastructure, raising a significant challenge around how to capture models and information about those works. Perhaps even more challenging will be capturing and holding legacy and historical information about the built environment long into the future.

- It is widely recognised that clients are the major beneficiaries from the cost savings and quality improvements that can be achieved through BIM and related information technologies. There is therefore a need for clients to become more informed about those opportunities and to exercise leadership in driving the adoption of digital technologies. Historically, the development of BIM has been bottom-up, initially driven by engineering and design professionals, then being taken up by the construction and manufacturing sectors of the industry and more recently by owners. The need for owners and clients to take action is even more significant since the greatest costs of owning any property, and therefore the greatest potential savings, occur during its operational life.

- Due to the diversified nature of the construction sector, there is no single voice that represents the full gamut of competing interests (though the current ACIF/APCC industry consultations are a step in that direction). This has led to a failure of the construction industry to effectively influence the development of government data policy in the built environment. Industry has to endeavour to find a collective voice through constructive dialogue and a willingness to embrace compromise. The spatial sector has been more successful in that sphere and can play a crucial role in facilitating the government conversation.

Driving the Integration of the Spatial and Construction Information

The previous section canvassed the opportunities and challenges associated with the development of the DBE through the integration of spatial and construction information. In this section we discuss the crucial roles of Government in driving innovation, recognising that it must be a collaborative partnership between Government and industry if Australia is to become a leader in this domain.

Here we list seven actions that could be taken by Government to accelerate the development and uptake of digital technologies and pave the way for the development of the DBE.

Establish new FSDF Theme – Built Environment

The first step towards integration is to recognise the essential role of construction information within the Australian and New Zealand Foundation Spatial Data Framework (FSDF)[47] by establishing a new FSDF Theme under the banner "Built Environment". This single act will create a Government-endorsed programme of work, appropriately supported through the Commonwealth Department of Communications and linked in strongly to the ANZLIC reporting framework. The first task of that Theme Leadership Group will be to develop a Target Operating Model and associated Roadmap as set out in the next section. Appendix B proposes a draft profile for the Built Environment Theme.

---

[47] ANZLIC. The Australian and New Zealand Foundation Spatial Data Framework: Making common foundation data ubiquitous across Australia and New Zealand, Commonwealth of Australia (Department of Communications), Edition 2, April 2014. Available on-line (accessed 11/07/15): http://www.anzlic.gov.au/__data/assets/pdf_file/0017/47321/FSDF_Booklet_edition_2_web.pdf

Establish a Commonwealth Office of the Digital Built Environment

Experience in the UK and elsewhere has demonstrated the value of government leadership, so there must be a concerted effort to fit that model to the Australian context, recognising the need for an appropriate response to the challenges created by the Commonwealth and State levels of governance. We have seen examples of Commonwealth action in developing a national building code or national land title standards: a similar action is required to integrate standards for the digital built environment.

Establish a Roadmap for the evolution of the Digital Built Environment

The DBE is fundamentally concerned with modelling the built environment down to a level of granularity that supports the full gamut of construction processes, while leveraging the spatial technologies to contextualise that information through links to the vast repositories of data created and captured by the spatial sector. To achieve that, a priority activity is the development of a Roadmap to achieve that integration.

Promoting innovation through Government procurement policies

As the largest procurer, owner and operator of infrastructure and buildings, Federal, State and Territory governments should play a strategic role in driving innovation in the adoption of BIM technologies and their integration with spatial information. There are enormous productivity and performance benefits to be derived in the efficient use of tax dollars to meet the challenges of global urbanisation. Governments throughout the world are recognising that opportunity and taking appropriate steps, and Australia is at risk of falling behind and losing the export market opportunity.

Expanded tools for accessing open data

Federal and state governments have taken initiatives with open data mapping portals which is commendable, but more needs to be done. Government leadership in integrating and adopting these technologies will have significant flow-on effects across the private sector as organisations re-tool to meet government expectations and apply that innovation to private development as well. The Open Data Institute in Queensland[48] provides a good model for developing this agenda.

Facilitate adoption through cross-industry initiatives

Through relatively modest levels of expenditure, government can sponsor cross-industry programmes and deliverables that facilitate the wider adoption of BIM and its integration with spatial information in ways that are impeded if left solely to industry. This includes the development of open standards, a national BIM object library based on agreed terminology and data specifications, guidelines for adoption, establishment of education standards and certification procedures, new forms of contract that recognise the role of ICT, etc. Such modest investment will be returned with huge interest, judging from the UK programme.

Support Local Government as a key stakeholder in the DBE

Local government do not currently have the tools to effectively manage their portfolios, and individually do not have the resources to capitalise on new technologies. That is a strategic point of contact between spatial and construction information, so is a critical beneficiary of an integration of those technologies. There is a role for State or Commonwealth Governments to facilitate the integration and therefore empower local government and stimulate effective use of integrated solutions.

---

[48] http://www.odiqueensland.org.au/about (accessed 11/07/15)

Roadmap for Integration of Spatial and Construction Information

Figure 12 on the next page sets out the steps required to establish a road map for the integration of spatial and construction information to deliver the DBE.

There are areas of specific technical work that have been identified as requiring significant support for their development. This is aimed to discourage proprietary formats in favour of open standards and data, establish open innovative delivery platforms, and meet the need to ensure integration with cross sector considerations. The technical work includes:

- Foundation Classes (Data Definitions)
    - Establishment of the DBE as a new theme in the FSDF
- Model View Definitions
    - Levels of Detail
    - Data Views
    - Security Access
- Platform considerations (National Map)
- Process Definitions
- Dictionaries and Ontologies
- Data and transaction provenance
- Geospatial specific open data considerations

The following phased development is recommended for developing the Roadmap for implementing the vision for DBE:

1. Establishment of a project office for BIM and DBE in Federal Government where it can have pan-Government outreach. Appoint a steering committee.
2. Establishment of a SIBA Knowledge Community specifically for BIM and DBE.[49] Knowledge Communities facilitate the aggregation of tacit knowledge on topics and support the engagement of multiple stakeholders.
3. Establishment of a Built Environment theme in ANZLIC's Foundation Spatial Data Framework (FSDF)[50]. FSDF provides a common reference for the assembly and maintenance of Australian and New Zealand foundation level spatial data in order to serve the widest possible variety of users. It will deliver a national coverage of the best available, most current, authoritative source of foundation spatial data which is standardised and quality controlled. The FSDF is an ANZLIC sponsored initiative.
4. Develop a Road Map (including Stakeholder workshops) – commencing with input from the Investment Logic Map (ILM), conduct a series of workshops with stakeholders. These stakeholders include Government, Private Sector and Academia with interests covering the construction, agriculture, mining and health industries.

---

[49] SIBA Knowledge Community http://www.siba.com.au/getattachment/Projects/Knowledge-Communities/Knowledge-Communities/SIBA-Knowledge-Communities-FAQ.pdf.aspx
[50] ANZLIC FSDF themes http://www.anzlic.gov.au/foundation_spatial_data_framework
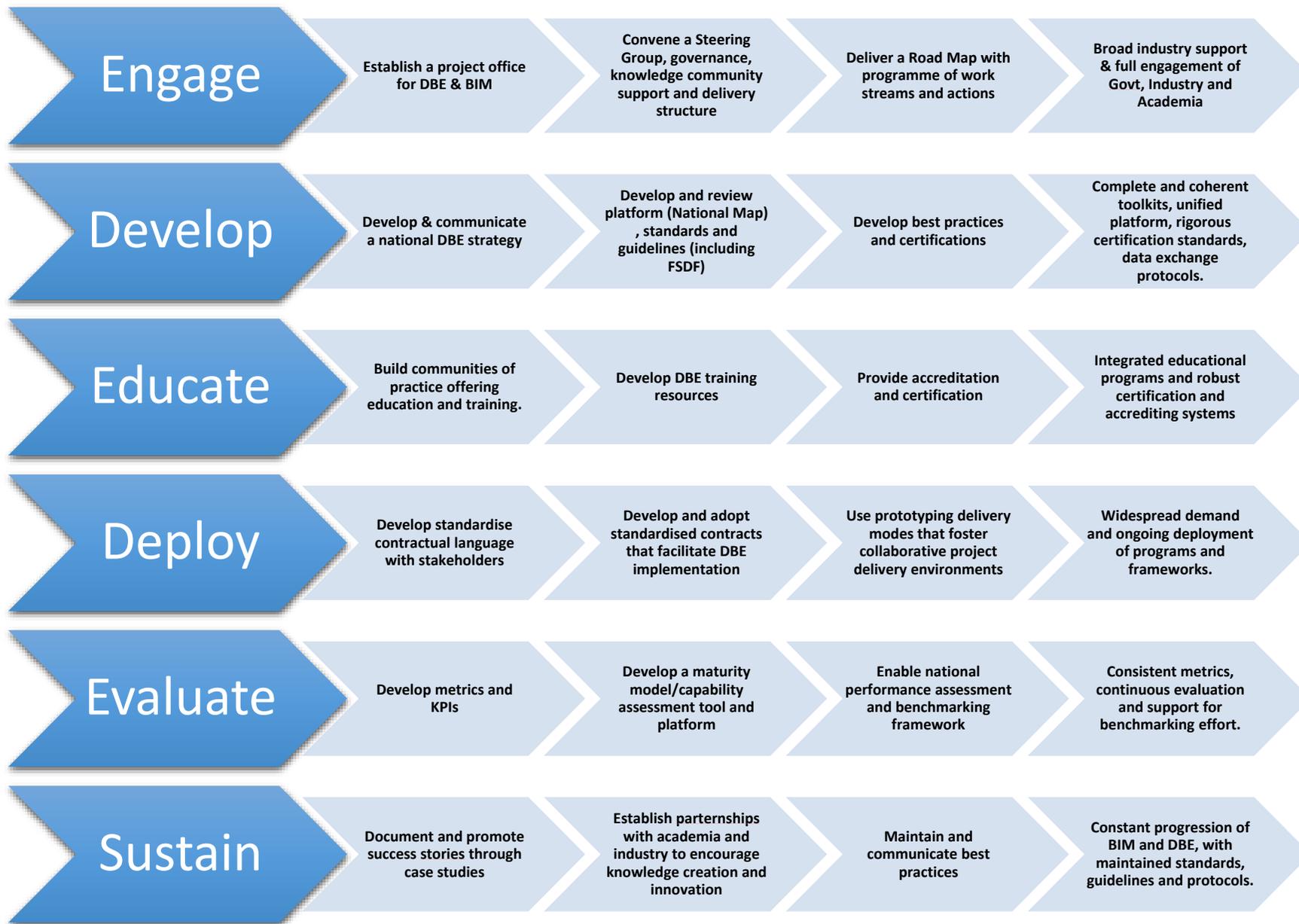
Engage	Establish a project office for DBE & BIM	Convene a Steering Group, governance, knowledge community support and delivery structure	Deliver a Road Map with programme of work streams and actions	Broad industry support & full engagement of Govt, Industry and Academia
Develop	Develop & communicate a national DBE strategy	Develop and review platform (National Map), standards and guidelines (including FSDF)	Develop best practices and certifications	Complete and coherent toolkits, unified platform, rigorous certification standards, data exchange protocols.
Educate	Build communities of practice offering education and training.	Develop DBE training resources	Provide accreditation and certification	Integrated educational programs and robust certification and accrediting systems
Deploy	Develop standardise contractual language with stakeholders	Develop and adopt standardised contracts that facilitate DBE implementation	Use prototyping delivery modes that foster collaborative project delivery environments	Widespread demand and ongoing deployment of programs and frameworks.
Evaluate	Develop metrics and KPIs	Develop a maturity model/capability assessment tool and platform	Enable national performance assessment and benchmarking framework	Consistent metrics, continuous evaluation and support for benchmarking effort.
Sustain	Document and promote success stories through case studies	Establish parternships with academia and industry to encourage knowledge creation and innovation	Maintain and communicate best practices	Constant progression of BIM and DBE, with maintained standards, guidelines and protocols.

Figure 12 Roadmap for Integration of Spatial and Construction Information

Integration of Geospatial and Built Environment National Data Policy

5. Tool & Workflow Prototyping – Identify feasibility prototype initiatives to illustrate core capabilities to inform organizational, policy and platform needs. The successful feasibility prototypes will evolve later into functional systems based upon a partial platform. Prototypes will enable stakeholders to benefit and also engage more specifically in defining the DBE

6. Core Platform staged development – From the outcomes of prototyping refine complementary cross management opportunities. Evolve the platform towards a comprehensive integrated digital ecosystem. Initially commencing with Aggregation, and extending to other core platform capabilities to close the cycle.

7. Scaling - Extend digital content and stakeholders - Take specific local solutions and extend these to address wider applications. Evolve the digital content to facilitate region-wide geographic and stakeholder requirements.

8. Institutionalisation - Develop policy, organisational and new revenue generation opportunities to couple with the digital ecology. This will have organization implications for example DBE could become a unit reporting directly to Department of Prime Minister and Cabinet (as in UK with BIM) to enable better inter-organisational, and delivery of outcomes.

9. Refinement - Continually evaluate and refine DBE against real societal, economic, and environmental needs using the CIPP Evaluation Model (Figure 13)[51].
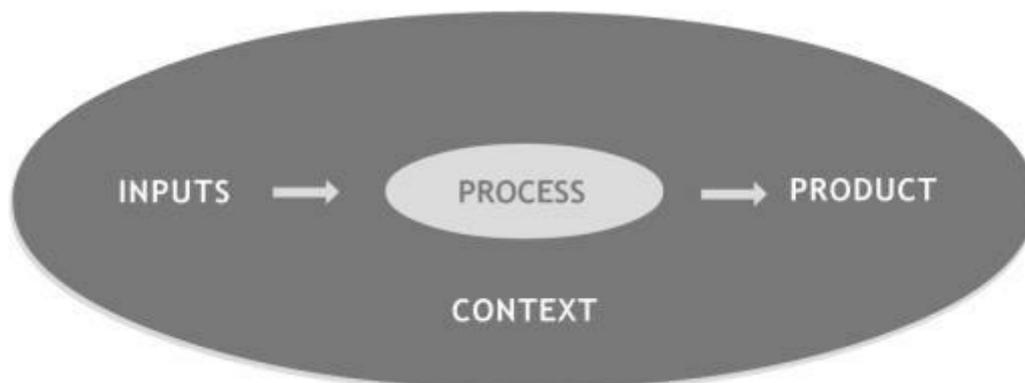

Figure 13 CIPP Evaluation Model is a robust framework for assessing' product' (outcome) in terms of Impact, Effectiveness, Transportability and Sustainability

From the Figure, aspects to consider are:

- Context of the process in terms of social, economic and environmental factors
- Inputs to the process
- The Process itself
- Product that is delivered through the process, considering
  - Impact
  - Effectiveness
  - Sustainability
  - Transportability

---

[51] CIPP Checklist http://www.wmich.edu/sites/default/files/attachments/u350/2014/cippchecklist_mar07.pdf

Proposed Time Frame

The proposed time frame for implementing this initiative requires the full support and commitment of the Federal Government. Should this be forthcoming, then the following time frame would address steps 1-6 from the list above and lead to the delivery of a strategic road map. After this date the resources will be appointed to start the journey of doing the steps outlined in the detailed strategic road map.

1.	ANZLIC Board Meeting and review of this document	28 July 2015
2.	Establish project Governance. Appointment a Government steering committee.	By 30 August 2015
3.	Establishment of a project office for BIM and DBE in Federal Government where it can have pan-Government outreach.	By 30 November 2015
4.	Establish a SIBA Knowledge Community	By 15 September 2015
5.	Develop a Strategic Road Map (including Stakeholder workshops and update of this document)	Commence once the Knowledge Community is established and complete by 30 December 2015. Milestones will be reviewed by Steering Committee
6.	Establish a Built Environment Theme for FSDF	TBA

Appendix A – Levels of BIM Maturity

BIM dimensions, from 2D to nD have been around for many years but are still being refined beyond 5D as various vendors and their marketeers seek differentiation and interest groups try, often asynchronously, to rationalise things. Below we sum up the current situation.

The basic work processes (Figure A-1) were developed through 2D paper to parametric (objects with interactive intelligence); however, many are still using 2D paper for passing information, losing a huge amount of both data and understanding in the process. Even where BIM has been used entirely as the medium from concept design to an 'as built' model for FM and operations support clients and planning authorities often demand paper, echoing managers who require their assistant to print out emails.
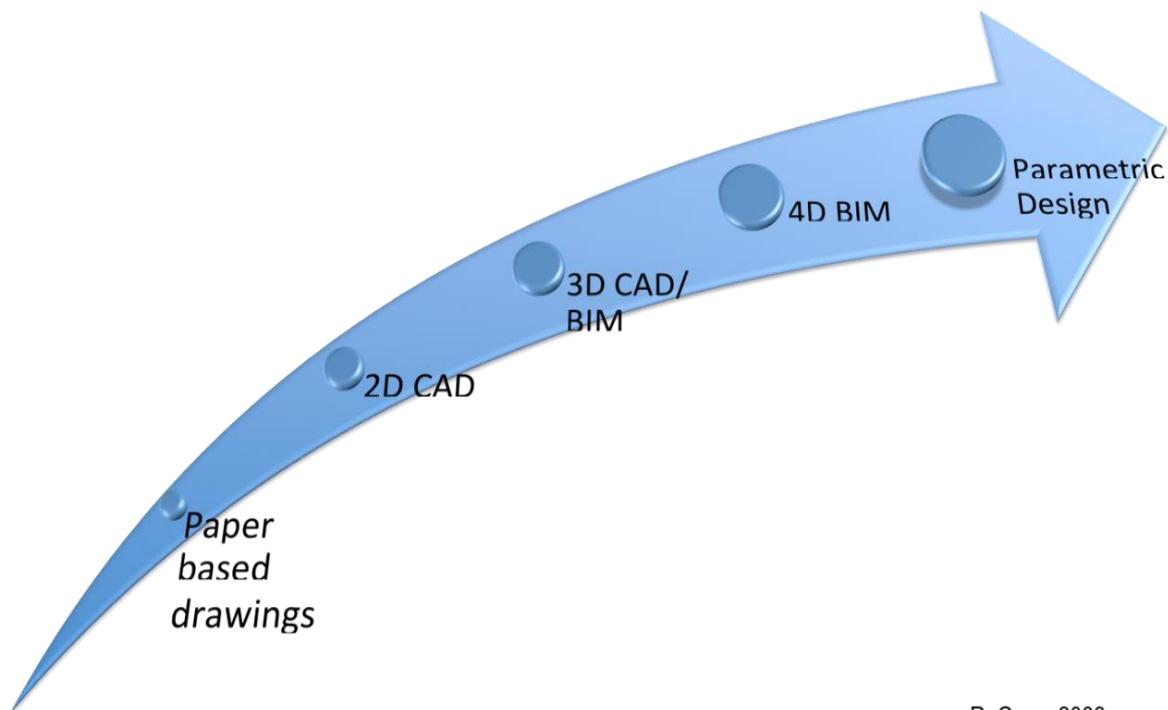
Figure A-1 Progression of Design Modelling paradigms (courtesy Robert Owen, 2008)

Paper-based and 2D CAD

Paper and 2D CAD drawings are self-explanatory and are remnants of the pre-computer age. Whilst isometric views and cross-sections have successfully enabled information recording and transfer, they are far from optimal and open to misunderstanding, especially by non-literate clients and other stakeholders.

3D CAD/ BIM: (space model)

3D was a substantial step forward in terms of data and design visualisation and only made possible through computing advances. Even so, today's technologies can still limit our ability to rotate views where substantial models are involved when pre-filtering has not been applied to the data. The model data sizes can also become huge, creating a need for shared model servers. In Cloud services this all becomes far more manageable as both data and data manipulations can be done remotely and yet the visualisations passed so quickly that it appears to be being manipulated on a desktop or laptop. BIM is generally CAD with an architectural and/ or engineering bias to the data structures, storage and representations. Some key advantages to using 3D BIM are:

- Interference checking within the BIM or with add-on programs
- Improved coordination, quality of design and transfer of information
- Semi-intelligent objects to optimise design and code conformance
- Creates better quality (fit for purpose) deliverables
- Client and community engagement through visually understandable representations of data.
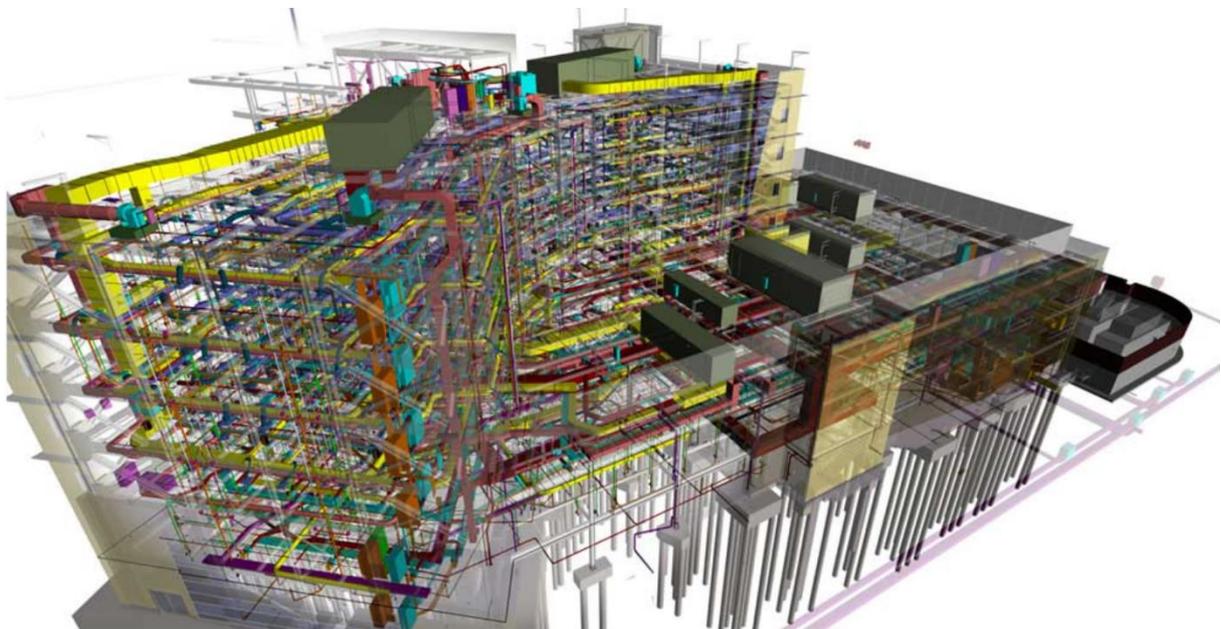

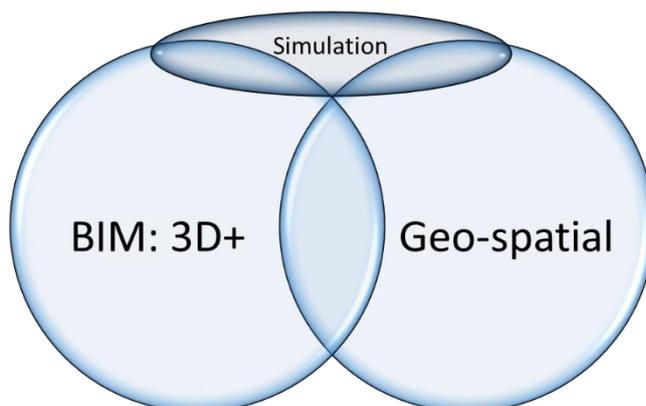*Figure A-3 Sutter Medical Centre Castro Valley Integrated Project delivery team BIM – Tekla (2014)*

Figure A-2 Building performance testing via Green Building XML (gbXML) and interference testing are facilitated for the BIM (R Simpson, 2015)

4D BIM (phasing/sequencing)

- 4D BIM is a 3D BIM that has objects and assemblies that have "schedule and time" constraint data added to them.
- The information can be contained in the BIM but is more usually integrated with a project management multi-industry product (eg. Primavera or Microsoft Project) or specialist construction scheduler (eg. Vico).
- Spatial gamification utilising serious-gaming technologies can be applied to demonstrate logistics and phasing. Gamification facilitates the application to pedagogy and knowledge mapping for purposes of scenario modelling, tuition, and capturing experience/ best practices. This is an area with very significant growth potential from what is currently a low application base.
- Digital Built Environment (DBE) enables extension beyond the building footprint to comprehend the impact on immediate precinct and wider urban context.

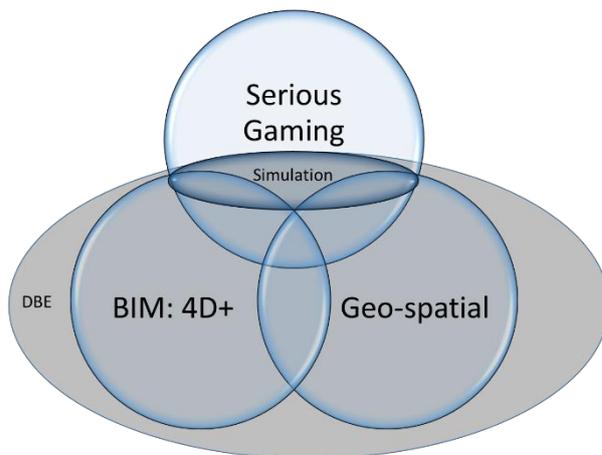*Figure A-5 4D Build over time (Image: Real Serious Games)*

Figure A-4 Through spatial gamification BIM:4D+ models can be used in scenario modelling, ,logistics analysis, learning, and simulation. Serious Gaming technologies also enable the mapping of behaviour to objects facilitating the capture of knowledge and pedagogy. This knowledge may be specific to the installation, maintenance, decommissioning or other purposing and interplay of objects within the context of the modelled environment. (R Simpson, 2015)

5D BIM (cost)

- 5D BIM is a 4D BIM that has objects and assemblies that have a "cost" dimension added to them. There is considerable scope for further development to integrate work processes costings.
- The cost information can be contained in the BIM or can be integrated with other costing software – Exactal CostX being an Australian international success story here.

Saves money through better understanding of costs and substantially improves timeliness of numerous re-costings typical on most construction projects
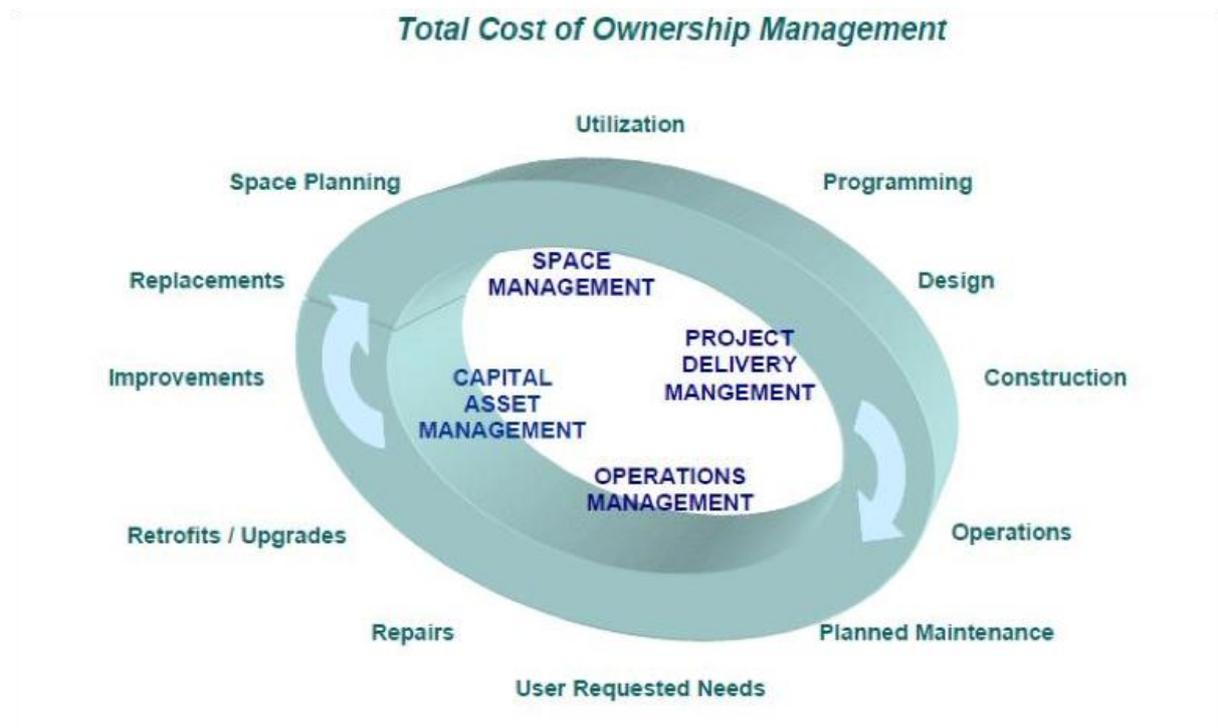
Figure A-6 4D 5D BIM – Strategic Total Cost of Ownership (source: P Cholakis, 2010, https://buildinginformationmanagement.wordpress.com/

6D to nD Modeling

Which dimension is which becomes obscure beyond 5D as different sources use the same number for different things. For instance, 6D was earlier often 'project lifecycle management' but is now often 'sustainability'. Eventually a consensus will form. The whole idea of being able to model the full lifecycle of a construction project is at the heart of current uncertainties. There are exceptional outliers where the client has defined exactly what they want, down to the design software, information storage, data exchange formats and model support period (eg. CrossRail) but this is very rare still. Many more do conduct sustainability analysis as they are often driven by a clients desire to attain a certain level of 'green' in their construction, which may explain why sustainability seems to be taking over the BIM 6D designation. We have taken the safe option and show the areas variously addressed, with their 6D/7D, etc designation.

Sustainability

- Sustainability analysis is needed for efficient sizing of items such as heating, ventilation and air conditioning (HVAC). More and more complex analyses are now becoming feasible, such as multi-building airflows and shadowing and façade optimisation for solar shading in order to reduce energy consumption.

- Highly scoring buildings under the US LEED, UK BREAM and less stressful Australian GreenStar rating systems not only add to owner and occupancy satisfaction and carbon reduction; it also adds value to the building in the real estate trading world.

Project life-cycle management information (sometimes called the FM Model).

- The project life-cycle management information can be contained in the BIM or can be linked or otherwise associated to the building and built environment objects.
- An "As-Built" BIM model is populated with all relevant building component information, such as product data and details, maintenance/operation manuals, cut sheet specifications, photos, warranty data, web links to product online sources, manufacturer information and contacts, etc.
- Requires Digital Built Environment (DBE) to enable consideration of context beyond the building footprint.
- Improves Procurement Processes through feedback (eg. The UK's 'Soft Landings' program).
- Operational life cycle
- Contains full operational life cycle management information.
- The costs of operation and delivered value vary hugely, dependent on the type of building or infrastructure. It is said that the ratio of building cost to operations and upkeep may be 1:4 or even 1:10, with the value of using the building/ infrastructure being another factor of ten to 100 above this. However, even where these have been studied on specific projects the results are open to question.
- Improves the Operational Life Cycle, particularly when occupants/ users are fully engaged.
- Requires Digital Built Environment (DBE)
- This may also include assessments of the 'Carbon footprint', although often now separately define (see above).

Figure A-7 London's Crossrail is working in a Level 2 "common data environment" (CDE) with collaboration between no fewer than 60 major contractors and 25 design consultants. (Image: CIOB- Chartered Institute of Building, UK)
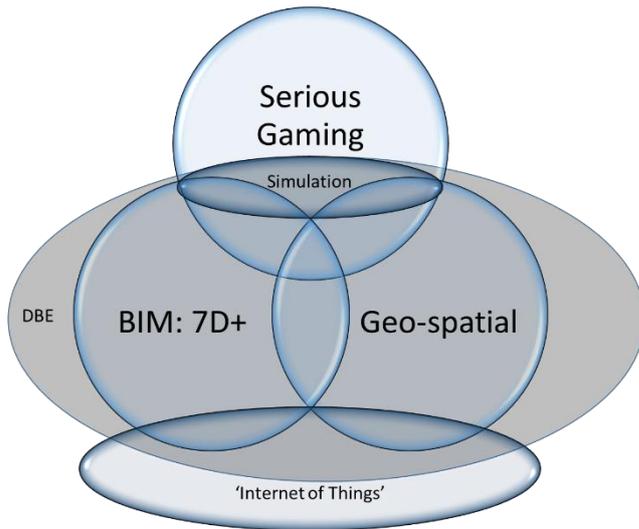
Figure A-8 Real time interfaces between the BIM and sensors is facilitated through complex networking with sensors. The Digital Built Environment (DBE) become the effective interface to couple the physical world with the digital world. (R Simpson, 2015)

Health and Safety

- BIM with safety management information.
- Construction methods of design elements and the risks faced by workers on site in the process of building the elements;
- Safe design suggestions for making design changes or incorporating safety devices in the design;
- Enhanced by the Digital Built Environment (DBE)
- On-site safety measures to eliminate or reduce the risks for hazards that could not be eliminated at the design stage.

Figure A-9 Planning to mitigate health and safety risks using BIM – Balfour Beatty (2015)

Appendix B – FSDF Theme – Built Environment

The Foundation Spatial Data Framework (FSDF) is an ANZLIC sponsored initiative and provides a common reference for the assembly and maintenance of Australian and New Zealand foundation level spatial data in order to serve the widest possible variety of users. It will deliver a national coverage of the best available, most current, authoritative source of foundation spatial data which is standardised and quality controlled.

Proposed Theme Narrative – Built Environment

Theme Sponsor

buildingSMART Australasia and the
Spatial Industry Business Association (SIBA).

What is the Built Environment?

The Built Environment refers to the human-made surroundings that provide the setting for human activity, ranging in scale from buildings to precincts to cities and include their supporting infrastructure, such as roads and rail, water supply or energy networks. The data needs of the Built Environment encompass the full and integrated asset lifecycle, from planning through design, construction and facilities management.

Built Environment data is held in, or may be converted to a Building Information Models (BIM) and may cover approved, unapproved, in-design, in-use or historical structures.

The challenge when managing access to this data is four-fold: the potential size of the total data set; respecting privacy & security concerns through effective access controls; the disintegrated nature of the data sources; the temporal nature of the data, maintaining the record as the Built Environment changes over time.

What datasets make up the Built Environment Theme in the FSDF?

The proposed Built Environment Theme is applicable to the modelling of buildings and building-related facilities or infrastructure, from a portfolio of assets at a single site or multiple sites to broad-scale transport infrastructure projects, including any constituent system, subsystem, component or element. It is applicable to any asset type, including most infrastructure and public works, equipment and material. BIM processes are applicable across the entire life cycle of a portfolio, facility or component, which can span inception to end-of-use.

The data is created for private purposes (design & construction, refurbishment or asset management), either by or on behalf of property owners or operators. Every entity in the built environment will have data that can be contributed to a federated, but distributed, information repository. Collectively, this is referred to as the Digital Built Environment (DBE). There is a need to create incentives and mechanisms to encourage stakeholders to make the data available.

The role of the theme sponsors is to develop strategies and policies that create a framework for the DBE to act as a foundation data source.

Why should the Built Environment theme be part of the FSDF and how could it be used?

In Australia and New Zealand the awareness of BIM is high and the drive for productivity and quality management is facilitating increased integration and collaboration of project teams.

The inclusion of the Built Environment as an FSDF Theme will:

- help ensure a consistent definition and format of model data;
- open opportunities for the introduction of more efficient and effective online approval process for construction of the built environment;
- better inform risk management in situations where sites may be susceptible to natural disasters, pose health/contamination risks or be deemed culturally significant;
- provide significant confidence to owners for data fidelity and availability over a building's life;
- facilitate better understanding of the built environment and city precincts, including the potential to make significant savings in construction;
- provide information support at a high level of detail for smart buildings, infrastructure, precincts and cities;
- facilitate new innovative markets for BIM and spatial industry services;
- accommodate improved briefing systems;
- demonstrate a national commitment to open format BIM (Open BIM); and
- provide impetus for improvement in the suite of open protocols for technical instruments.

Other benefits may be realised for post construction building management, building approval and compliance, operation and maintenance using the COBie Standard (or others such as ISO, bsDD, SPie etc.) that helps organise information about new and existing facilities. These standard is general enough that it can be used to document both buildings and infrastructure assets; it is simple enough that it can be transmitted using a spreadsheet.

Standards

The global BIM standards incorporate "business views" of information exchanged between all players in the design, construction and approval processes, as well as supporting asset owner / operator interests. The Open Geospatial Consortium (OGC) is now working closely with buildingSMART International in the development of a new generation of exchange standards built upon standards in use today, particularly:

- The buildingSMART suite of standards, including IFC, IDM, MVD and bsDD
- Standards of the National Institute for Building Sciences
- ISO standards
- Open Standards Consortium for Real Estate (OSCRE) standards
- Open Geospatial Consortium (OGC) standards
- The FIATECH capital investment roadmap
- Efforts like CSI OmniClass or the UK UniClass taxonomies, US and UK COBie (Construction to Operations Building Information Exchange), etc.
- ISO/TS 12911:2012 establishes a framework for providing specifications for the commissioning of building information modelling (BIM).

ISO Standards originated for the global use of BIM technologies are:

- ISO 16739-12:2012 Building Information Modelling IFC4

- ISO 12006-2:2001 Building construction - Organization of information about construction works - Part 2: Framework for classification of information
- ISO 12006-3:2007 Building construction - Organization of information about construction works - Part 3: Framework for object-oriented information
- ISO/POS 29481-1:2014 Building information modelling - Information Delivery Manual- Methodology and format
- ISO 29481-2:2012 Building information modelling - Information Delivery Manual - Interaction Framework
- ISO 29481-3:2012 Building information modelling - Information Delivery Manual - Model View Definitions
- ISO TS 12911-2012 Framework for building information modelling (BIM) guidance
- ISO/FDIS 16354 Guidelines for knowledge libraries and object libraries
- ISO/CD 16757-1 Product Data for Building Services System Models -- Part 1: Concepts, architecture and model
- ISO/CD 16757-2 product data for building services system models - Geometry
- ISO 81346-12 Industrial systems, installations and equipment and industrial products– Structuring principles and reference designation
- ISO/AWI 19650 Specification for information management for the capital/delivery phase of construction project using building information modelling
- COBie MVD (see http://docs.buildingsmartalliance.org/MVD_COBIE/)

Australian building standard activities are managed by the SA Committee BD-104 Building Information Modelling (Australian Mirror Committee to ISO TC 59/SC 13 Organisation of information about construction works).

These are technical protocols for the formatting and management of model-based information. In addition, the industry requires guidelines and reference methodologies to create, manage and deliver BIM based projects.

In the UK, the government through their UK BIM Task Force has facilitated the development of Guidelines working with industry in their formulation. There are a number of guides in the PAS 1192 series, including:

- PAS 1192-2:2013 Specification for information management for the capital/delivery phase of construction projects using building information modelling
- PAS 1192-3:2014 Specification for information management for the operational phase of assets using building information modelling

In Australia, NATSPEC has been active in developing BIM guides, including the National BIM Guide and a BIM Paper entitled the BIM Project Inception Guide. They have also undertaken to develop a National BIM Library, releasing an initial report, National BIM Object Library Survey.

Future Status

The DBE will ultimately include all that is known about the constructed built environment. As such, it will form an essential piece of digital infrastructure to support the smart cities of the future. It must be delivered in non-proprietary data formats through effective security frameworks that protect the privacy and security of individual property owners, while opening up appropriate access to all available information.

The Built Environment Theme Sponsors will develop a comprehensive roadmap, detailing steps to engage, develop, educate, deploy, evaluate and sustain the DBE in its desired future state.

Acknowledgement of Contributors

About the Authors

Jim Plume

Jim Plume is a current Board Member of buildingSMART Australasia and a member of InfraCom, the executive committee of the InfraRoom Steering Committee, within buildingSMART International. He has also just been appointed Co-Convener of the Integrated Digital Built Environment Working Group, newly established by buildingSMART International to develop a conceptual framework and associated work plans to guide the international standards work of buildingSMART in the area of the digital built environment, working is collaboration with OGC and other standards bodies. He is a member BD-104, of the Australian Mirror Committee for ISO/TC 59/SC 13 (organization of information about construction works) and the liaison between that Committee and IT-004, the Australian Mirror committee to ISO/TC 211.

These professional activities are founded on just over 40 years of research, scholarship and teaching in the area of information modelling and digital technologies for the built environment disciplines. His pursuit of that field began as an undergraduate architecture student in the early 1970's and was cemented during his postgraduate research work where he implemented a prototypical building modelling application running on a Cyber mainframe computer. After a short period in architectural practice where he experimented with early, pre-CAD architectural drawing systems, he took up an academic post at the University of New South Wales in what is now the Faculty of Built Environment.

During a period of 30 years in that post, he was instrumental in guiding the establishment of Faculty IT resources, developing and delivering teaching IT curricular at both undergraduate and postgraduate level, exercising academic leadership in senior posts in the Faculty and undertaking research in the evolving area of building information modelling and related fields. He introduced the first compulsory BIM course into a professional built environment program in 2002, and in 2004 established a pioneering multidisciplinary studio course in collaborative design using BIM.

In 2008 he commenced a 2-year ARC-funded Linkage Research Project called UrbanIT, which was a foundational piece of research investigating how BIM technologies can be extended to encompass an urban region and, in particular, position a BIM within its geospatial context without losing its semantic integrity. That work has led into his current research on Precinct Information Modelling (PIM), funded through the CRC for Low Carbon Living at UNSW Australia. The aim of that project is to develop an open data model schema and associated object component library to support precinct-level assessment and management to achieve carbon abatement in the built environment. That work provides an essential bridging element between construction and spatial modelling, and informs many of the ideas contained in this Position Paper.

Richard Simpson

Richard Simpson is currently CEO of Spatial Industries Business Association Queensland. He was a co-founder of New Zealand's first 3D computer graphics company, led development of spatial platforms now deployed across 80 nations, and is a former Auckland City Councillor and Chair of Transport. He has had a professional interest in the development of technology for the spatial industry for over 25 years.

In 1991 he designed and led development of the world's first implemented prototype for automated building compliance checking system for the assessment of 'intelligent' CAD models. The prototype scraped a topology from a CAD file and then submitted this to an expert system to the check compliance against a rule base with the fire regulation. The success of this initial prototype led Building Construction Authority (BCA) of Singapore to initiate the CORENET (Construction and Real Estate Network[52]) electronic consent submission system in 1995 and later update it to support the 3D IFC model.

Following the Christchurch Earthquake he was commissioned to run a series of workshops on implementation of BIM with the New Zealand Government and building executives and was a lead adviser the New Zealand Government on the visionary and influential Geobuild initiative. He also led the development of a working prototype of Geobuild[53]. Geobuild was officially launched [54]at the Digital Earth Summit held in Wellington in 2012.

---

[52] Singapore Government's CORENET site https://www.corenet.gov.sg
[53] Demonstration of the Geobuild prototype https://vimeo.com/88965567
[54] Keynote by Simon Lloyd-Evans for launch of Geobuild https://www.youtube.com/watch?v=ZJjRi_UhdVQ

The Geobuild[55] initiative brought together three components of the Digital Building Environment (DBE):

- A National Online Building Consent System – led by the Dept of Building and Housing

- Acceleration of the use of Building Information Modelling (BIM) – joint Dept of Building and Housing / Productivity Partnership

- An enhanced national and local Geospatial Information Strategy (GIS) – led by Land Information NZ (LINZ)

He was also the original architect of the Visual City platform now being deployed in the rebuild of Christchurch and other cities to integrate BIM within a spatial Digital Built Environment (DBE).

He has co-authored two books[56] relating to the Digital Built Environment and has been an author on 4 scientific papers published in leading international journals over the past 3 years, including the much cited landmark paper 'Next Generation Digital Earth'[57] published in the Proceedings of the National Academy of Sciences (PNAS). He is currently the Chair of the International Society of Digital Earth's (ISDE) Working Committee on Digital Cities.

Robert 'Bob' Owen

Bob Owen came to the Queensland University of Technology (QUT) in 2012 to lead Building Information Modelling (BIM) adoption in the Institute for Future Environments and School of Civil Engineering and Built Environment, along with construction sector improvement in general. He was then asked to set up QUT's cross-discipline Spatial Hub whilst continuing his work with the construction sector. This year he was asked to establish and lead the International Council for Research and Innovation in Building and Construction's (CIB's) Infrastructure Task Group.

Whilst in the UK he was Senior Research Fellow at the University of Salford, working in agile project management, lean construction, BIM and collaborative contracting. He played a catalytic role in the creation of the UK's world-leading BIM program and hopes to be a part of the next generation Digital Built Britain – Research program announced this year. Whilst at Salford he also led the CIB Integrated Design and Delivery Solutions priority research program.

Bob has been involved in a very wide range of projects and research, including electronic warfare, imagery analysis, as a member of the NATO Advisory Group for Aerospace Research and Development (AGARD), as UK Expert in Project Management to ISO, to today's building and infrastructure process improvement.

The UK BIM program was announced this year to have saved the UK taxpayer £840M in 2013/14 (its trial year) and is expected to save £1.2Bn this year.

Alan Hobson

Alan is the Champion of the SIBA Knowledge Community for BIM. He represents SIBA on the Sustainable Built Environment National Research Centre (SBEnrc): Project Steering Group for two

---

[55] An overview presentation of Geobuild http://econtent.tauranga.govt.nz/data/building/files/geobuild.ppt

[56] Energy Efficient Design of Buildings (TG, 1995) ; and D_City : Digital Earth|Virtual Nations|Data Cities Manifesto http://dcitynetwork.net/manifesto/ (GEOS, 2012)

[57] 'Next Generation Digital Earth' (PNAS July 10, 2012) http://www.pnas.org/content/109/28/11088.full.pdf

projects relating to BIM, namely *National Building Information Modelling (BIM) Guidelines and Case Studies for Infrastructure*; and *Using Building Information Modelling (BIM) for Smarter and Safer Scaffolding Construction*. He is currently participating on two further projects namely, *New Project Management Structures: Infrastructure Modelling (BIM) and Location (GIS)*, as well as *Driving Whole-of-Life Efficiencies through BIM and Procurement*.

He is a member of BuildingSMART and was an inaugural committee member of Consult Australia's BIM Round Table initiative. He holds the position of Deputy Chair for the Spatial Information and Cartography Commission of the Surveying and Spatial Sciences Institute (SSSI). For a while he participated on the SSSI Consultative Council. He was an inaugural member of the Asset Design and As-Constructed (ADAC) Steering Committee made up of five participating SEQ LGAs several years ago. Since then this initiative has matured into an industry standard in Queensland.

Alan has held various leadership roles in both the private and public sectors. He has been a catalyst for knowledge sharing and capability development within departments and between operating businesses of an international Design & Construction company. He promotes integration towards efficiency based on practical experience from project delivery and management of teams. Under a remit of project management he has integrated Geospatial, Real-Time Visualisation and BIM (previously called VDC) services into large and small projects in the sectors of mining, transport, energy, water, local government and environment. To mention one project, he had a pivotal role in the Ipswich Motorway Upgrade (IMU) - Dinmore to Goodna, Origin Alliance project (2008- 2012), Ipswich, Queensland, Australia, Department of Transport and Main Roads (project value: $1.95b). Alan was the Division Leader responsible for VDC/BIM, GIS and Visualisation services. The success of the overall project is highly recognised as it was completed six months ahead of schedule and 10% under budget.

Alan was invited by the Department of Defence in 2014 to participate in an inaugural Facilities Management Workshop with the purpose to consider an approach to implementing BIM and IPD in the Infrastructure Division of Defence's next generation suite of contracts.

Alan has published 6 technical journal articles, contributed in 14 conferences papers and participated in 5 technical forums, all these covering various topics relating to fields of planning, design, construction and facility management.

Position Paper Preparation

About buildingSMART Australasia

buildingSMART Australasia is a not-for-profit industry group representing Australia and New Zealand as one of 17 regional chapters across the world (spanning 24 countries) that collectively forms buildingSMART International.

buildingSMART's overriding objective is to produce much better built infrastructure - buildings and other facilities that the community values, that meet real needs, that perform better, that impact the environment less, that take less time and money to build and operate more effectively. The national adoption of BIM is a critical part of that broad objective.

Our members are drawn from across the industry, including:
- Building owners and developers (both Government and private);
- Architects, engineers and related design, planning and authority professionals;
- Buildings, sub-contractors, product and materials suppliers; and
- Related service providers.

As an international, non-profit industry association, buildingSMART International's core goal has been the development of open standards that support information exchange throughout the life-cycle development of buildings and civil infrastructure projects. The IFC standard (ISO 16739) specifies a neutral BIM format that ensures high quality, reliable information exchange between all parties in the development and management of an asset.

Over the last three years we have developed – with broad Australasian consultation – the *National BIM Initiative* setting out a strong business case for the national adoption of BIM with detailed priorities for implementation; and we have collaborated with APCC/ACIF on their *Framework for the Adoption of Project Team Integration and Building Information Modelling* which identifies the key elements, underpinned by objectives and actions, that will see a collaborative 'whole of industry' approach to both encourage and support an increased adoption of PTI and BIM.

Although the Australian Government has expressed support for BIM, it is yet to commit any significant resources to promote the widespread adoption of these technologies across the construction sector. buildingSMART Australasia continues to play a major role in lobbying Australasian Governments to recognise the national benefits of investing strongly in the promotion of BIM.

This paper – providing a detailed insight into the way the two technologies of geospatial and BIM are merging, and the extended benefits of this merger – further informs our understanding how the digital technologies can innovate and transform the way we develop and inhabit the built environment.

To find out more about buildingSMART Australasia, see here: http://buildingsmart.org.au

About Spatial Industries Business Association Ltd (SIBA)

In September 2001, the then Minister for Industry, Science and Resources, Senator Nick Minchin, released the Spatial Industry Action Agenda Report, Positioning for Growth. One of the first things the Action Agenda process created was the (now) Spatial Industries Business Association (SIBA), which represents the business interests of some 400 companies throughout Australia.

SIBA has been an important contributor to key government policy imperatives. In 2003 the then Deputy Prime Minister, John Anderson, commissioned ASIBA, together with the NSW Division of the Australian Property Institute (API), to develop a definition for a property right in water. In March 2004, ASIBA presented to the Deputy Prime Minister the final report titled An Effective System of Defining Water Property Titles, which was the foundation for the National Water Initiative.

Recently, the OECD has referred to this work as "world leading".

Throughout its short life, SIBA has contributed to policy debate on water, salinity science, bushfires and security. Governments now consider spatial information and technology to be essential infrastructure and management tools. SIBA has also been a leader in bridging the web services gap with its recently completed and much lauded Spatial Interoperability Demonstration Project (SIDP).

This Project produced technical documentation to support spatial interoperability solutions for emergency management and the insurance and utilities sectors. Much of SIBA's work in delivering the interoperability Project has already been acclaimed around the world. The international standards body for exchanging spatial information, the Open Geospatial Consortium (OGC), has

asked permission to use one of our documents as an international White Paper on interoperability. The Project is a tribute to cooperation across the public and private sectors, the states, territories and commonwealth.

As the premier business representative body in the spatial information arena, SIBA speaks for its member firms in a range of forums on land and land-legal matters. SIBA also contributes significant public comment through its awareness programs in the Australian popular press.

In 2004 the association expanded to incorporate New Zealand, which resulted in revising the name to Spatial Industries Business Association (SIBA).

Today, SIBA represents companies in the spatial industries through submissions to government, facilitating business opportunities, networking events, specific business tools and direct business support.

SIBA's work on key policy issues will have a significant and positive impact on the Australian community and economy for many years to come.

To find out more about SIBA, see here: http://SIBA.com.au.

About the Collaboration

buildingSMART Australasia and SIBA have come together to collaborate on the preparation of this Position Paper to reinforce the emergence of the Digital Built Environment (DBE) as a critical and fundamental building block for the evaluation of the performance of a sustainable community. The scope of the spatial industry embraces both the built environment and the natural environment, so Building Information Modelling (BIM) is of significant interest to SIBA members as it is a workflow that enables collaboration for different stakeholders at the different phases of the life cycle of an asset to review, monitor and program the relevant course of action.

"A Building Information Model (Model) is a digital representation of physical and functional characteristics of a facility. As such, it serves as a shared knowledge resource for information about a facility forming a reliable basis for decisions during its life cycle from inception onward."[58]

Hence SIBA is working closely with BuildingSMART Australasia to address the challenges and embrace the opportunities of the Digital Built Environment.

---

[58] Building Information Modelling Dana K. (Deke) Smith, FAIA - Executive Director, buildingSMART alliance, and Alan Edgar, Chair - National BIM Standard Project Committee – extract from the website http://www.wbdg.org/bim/bim.php