Towards a National Strategy

Research Report 1

SBEnrc - Integrated Project Environments

Leveraging Innovation for Productivity Gain Through Industry Transformation (Project 2.24)

This document is the first of three primary deliverables from this project to address the objectives: (i) inform a national strategy for the adoption of BIM/VDC, (ii) develop guidelines for new contractual frameworks and (iii) inform a strategy to reduce skill gaps especially for SMEs, within the context of Integrated Project Delivery in Australia.

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Executive Summary

This project aims to deliver on five important areas:

(i) Recommendations for policy makers for a nationally consistent strategy for adoption of integrated project environments (which also aligns as far as possible with international BIM standards and processes).

(ii) Recommendations for modifications of current procurement and contractual framework to allow more collaborative and building information modelling (BIM) enabled project environments.

(iii) Development of a dissemination strategy to different levels of the supply chain through our work with organisations such as CCF, EA and Austroads, as well as through our partner organisations and SBEnrc media resources (e.g. YouTube channel and industry publications).

(iv) Build an understanding of knowledge dissemination and skills development required to facilitate increased uptake of digital technologies and integrated project delivery (IPD).

(v) Explore the role of a consensus-driven peak body to coordinate uptake of BIM and IPD in the Australian construction industry.

The uptake of integrated project environments will play a critical role in fostering Australian competitiveness in the future. This research was based on strong collaboration between industry, government and researchers both in Australia and internationally.

This report addresses the first and last of these objectives, and provides a discussion of six key themes identified as relevant to the development of national strategy for IPD and BIM uptake: (i) lead agent role; (ii) client role; (iii) mandates; (iv) pilot projects; (v) metrics; and (vi) standards.

These issues are considered relevant to a national strategy for adoption of integrated project environments in that:

(i) The development of such a strategy will require the leadership and coordination of lead agents, and engagement with lead industry associations is important in the dissemination and industry leadership.

(ii) The primary transport infrastructure clients are state and territory government agencies. As such, these organisations are in a unique position to influence the uptake of new technologies and processes.

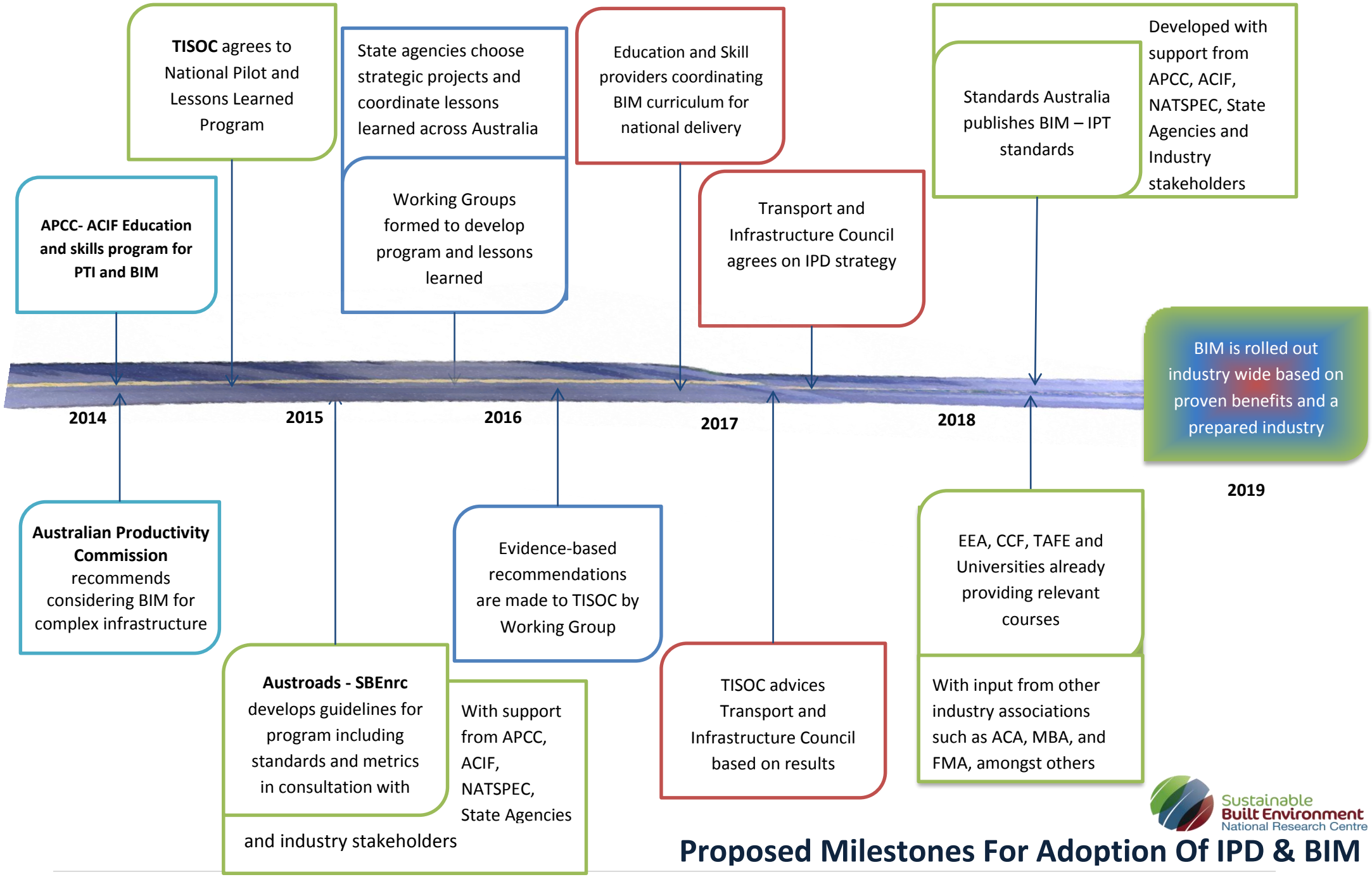
(iii) Pilot projects have the capacity to build a knowledge base especially in terms of productivity benefits and processes associated with the uptake of BIM and IPD.

(iv) A national mandate has been shown, by international comparators, to provide the industry with the incentive and consistency to invest in the development a pipeline of coordinated actions.

(v) Building consensus on standard performance indicators and metrics to prove the business value of BIM and IPD in terms of project, business and industry-wide benefits.

(vi) The development of national standards provides a consistent framework for uptake that increases productive and reduces industry cost.

Mapping the relevant industry peak bodies in Australia and Sweden provided evidence for the identification of the role and impact of different organisations on the uptake of new information technologies in the transport infrastructure industry. This led to the development of a set of milestones for IPD and BIM adoption in Australia based on current activity and showing the domino effect that each action would have on the industry.



Sustainable Built Environment National Research Centre

Proposed Milestones For Adoption Of IPD & BIM

1. Introduction to Integrated Project Delivery

The American Institute of Architects (AIA) and the Associated General Contractors of America (AGC) (2011) argue that traditional procurement models in the construction industry often promote adversarial processes along the supply chain built into the delivery process. Hence, more collaborative non-traditional models that facilitate communication, reduce risk and maintain reasonable profits are desirable and currently being developed across the globe.

Integrated Project Delivery (IPD) is one such model, where by integrating the project organisations and processes the team can create built environments that *perform better and are designed, built, and operated more efficiently while fully leveraging new technologies* (3xPT Strategy Group, 2007).

IPD is not tied to a single type of contract but rather forms a set of principles that can be applied to a variety of contractual arrangements (AIA, 2007). Table 1 illustrates key differences between traditional project delivery models and IPD according to AIA (2007).

Table 1. Differences between traditional project delivery models and IPD (AIA, 2007)

Traditional Project Delivery		Integrated Project Delivery
Fragmented, assembled on *just-as-needed* or *minimum-necessary* basis, strongly hierarchical, controlled	teams	An integrated team entity composed key project stakeholders, assembled early in the process, open, collaborative
Linear, distinct, segregated; knowledge gathered *just-as-needed*; information hoarded; silos of knowledge and expertise	process	Concurrent and multi-level; early contributions of knowledge and expertise; information openly shared; stakeholder trust and respect
Individually managed, transferred to the greatest extent possible	risk	Collectively managed, appropriately shared
Individually pursued; minimum effort for maximum return; (usually) first-cost based	compensation/ reward	Team success tied to project success; value-based
Paper-based, 2 dimensional; analogue	communications/ technology	Digitally based, virtual; Building Information Modelling (3, 4 and 5 dimensional)
Encourage unilateral effort; allocate and transfer risk; no sharing	agreements	Encourage, foster, promote and support multi-lateral open sharing and collaboration; risk sharing

Ideally, IPD brings the expertise of key actors from construction management, trades, fabrication, suppliers and product manufacturers to owners and design professionals earlier in the design and delivery process. This allows the production of a design that is optimised for quality, aesthetics, constructability, affordability, timeliness and seamless flow into lifecycle management (McGraw Hill Construction, 2008). Additionally, higher integration of the design-procurement-construction process can have long-term, industry wide benefits such as higher rates of technology transfer and innovation (Lemer & Dibner, 1992).

Widespread use of IPD principles could also help public clients to cope with the challenges identified by Yates (2012) (endorsed by Engineers Australia), and address some of his recommendations including:

- *Introducing consolidated procurement reporting.*
- *Standardising procurement work practices and introducing common contracts across an agency and government.*
- *Improving industry relations to allow better sharing of risks.*

According to the Australian Built Environment Industry Innovation Council (BEIIC) the principles of integration and collaboration will come to define how the industry is organised (BEIIC, 2012). With growing adoption of these principles the skilling of the workforce and definition of new contractual clauses will represent key steps towards more integrated project environments. This will foster more efficient and profitable linear infrastructure construction projects that also exhibit less risk to the supply chain as a whole.

This report summarises the findings from research carried out under SBEnrc project 2.24 *Integrated Project Environments: Leveraging Innovation for Productivity Gain through Industry Transformation.* The report focuses on those research results that pertain to the development of a national strategy to increase uptake of IPD and BIM in Australia and provide recommendations for a set of milestones.

2. Building Information Modelling in IPD

Digital technologies such as Building Information Modelling (BIM) are considered enablers of IPD and agents of change that allow the integration of disciplines, industry participants and construction phases including design, fabrication, assembly and delivery (BEIIC, 2012).

IPD leverages the power of modelling to facilitate collaborative decision making (McGraw Hill Construction, 2008). The 3xPT Strategy Group, formed by the Construction Users Roundtable (CUR), AGC and AIA, concluded that project information that supports the analysis, visualisation, communication, and decision-making during the IPD process is best represented and shared though BIM (3xPT Strategy Group, 2007). Furthermore, AIA (2007) states that although IPD projects can be carried out without the use of BIM, the full potential benefits of both are only achieved when used in conjunction (AIA, 2007). Succar (2009) goes one step further, stating that IPD is the ultimate goal and final maturity stage of BIM implementation.

BIM can be described as *a set of interacting policies, processes and technologies generating a "methodology to manage the essential building design and project data in digital format throughout the building's life-cycle"* (Succar, 2009). In this sense, BIM can be seen as more than *a digital representation of physical and functional characteristics of a facility* (Barlish & Sullivan, 2012) or a *collection of defined model uses, workflows, and modelling methods used to achieve specific, repeatable, and reliable information results from the model* (NATSPEC, 2011).

Mature BIM is a *socio-technical system* that can be used to improve team communication throughout the project life cycle, produce better outcomes, reduce rework, lower risk, and improve both predictability of outcomes and operation and maintenance of assets. These are some of the benefits identified by the US infrastructure sector (McGraw-Hill Construction, 2012).

The British Standards Institution has pointed out that *BIM technology is considered invaluable to the delivery of a construction project since it provides a common single and coordinated source of structured information throughout the lifecycle of a project* (BSI, 2013).

BIM promises the ability to create models that combine data which was traditionally spread across multiple documents along with the ability to share information between different models for the production of superior design solutions (McGraw Hill Construction, 2008).

An additional benefit of using BIM is that once information is created, it can be indefinitely reused, resulting in less errors, greater consistency, clarity, accuracy, and clarity of authorship (Furneaux & Kivits, 2008)

The use of BIM promotes clearer, more accurate, up-to-date communication by consolidating currently disparate project information. It allows all team members to contribute to the establishment and population of the databases underpinning the planning, design, construction and operation of the asset (APCC & ACIF, 2009).

> *If clients had a digital model of all their roadworks, they would be able to understand exactly what their maintenance requirements would be for the next 20 years. They can therefore manage their budgets for the next 20 to 30 years. They can predict with far greater accuracy what they're trying to do, they could resolve design issues, they could plan their infrastructure growth far more effectively*
>
> **Australian Contractor**

Models also allow for more accurate costing estimations in earlier project phases (AIA, 2007). It has also been argued that the adoption of BIM has the potential to increase the productivity of the Australian construction sector by up to 9% with high benefit/cost ratio (Brewer, Gajendran, & Le Goff, 2012). This would for example lead to an increase in Australia's GDP of up to AUD 7.6 billion for the period 2011-25, based on the building network alone (Allen Consulting Group, 2010).

3. BIM in Australia and Internationally

The Australian Bureau of Statistics (ABS) has established information and communication technologies, such as BIM, as one of the three core dimensions of knowledge-based economies (Trewin, 2002). It has also been argued that the way in which countries *master and use these technologies "is the key to their future economic performance"* (Ofori, 2002).

In early 2014, the Australian Government Productivity Commission made a series of recommendations to the infrastructure industry where Building Information Modelling (BIM) and models with early contractor involvement were featured. Among other things, this report highlighted that: (i) there is a *widespread view that there was scope for more innovation and diffusion of new technologies in the industry;* (ii) *given the potential savings from BIM, government clients should consider* the use of BIM from early design stages; and (iii) *while it is in governments' best interests to pursue these reforms, it can hardly be said that reform has proceeded either apace or uniformly throughout Australia,* hinting to the need for a more efficient nation-wide strategy (Australian Government Productivity Commission, 2014a).

3.1. International Best-practice

In the UK, the government identified construction as an enabling sector for their industry strategy and decided to become a world leader in BIM by: (i) committing to the BIS BIM Program (developed by the Department of Business, Innovation and Skills); (ii) aim for growth; and (iii) help create their future by continually developing their capabilities (HM Government, 2012). This decision was followed by a concerted effort between government and industry peak bodies that: (i) led to a series of legal, economic and operational reforms (Melville, 2008) and (ii) allowed these intermediaries to "directly participated in policy development through systemic approaches with the policy process" (Strickland & Goodes, 2008). The government chose to have a national *push-pull* strategy with a number of reforms to be undertaken over the next few years to reach level 3 of their roadmap (Figure 1) (BIM Industry Working Group, 2011).

In Scandinavia, Finland was one of the pioneers in this area. The RATAS project (which stands for computer aided design and buildings) originated from discussions in 1982 about the need to integrate information technology (IT) applications in construction. This was part of a coordinated research, development and standardisation effort to bring computer integrated construction to Finland (Björk B.-C. , 1993). This project identified BIM as the central issue in using IT for a more efficient construction industry and brought together most of the Finnish industry key players to develop a roadmap (Björk B.-C. , 2009). Nowadays, Finland requires the use of BIM for government procurement (Mitchell, Plume, Tait, Scuderi, & Eastley, 2012) and is seen as the BIM leader of Europe (RYM Oy, 2014).

Sweden has followed into the steps of Finland and also initiated concerted efforts to increase a nation-wide implementation of BIM. This led to the launch of the non-profit organisation OpenBIM (now BIM Alliance) in 2009 to establish BIM standards in Sweden. Public organisations such as the Swedish Transport Administration (Trafikverket) also mandated the use of BIM from 2015 (Trafikverket, 2013c) as part of their nation-wide efficiency program (Albertsson & Nordqvist, 2013). As part of their strategy, Trafikverket also developed legal guidelines on digital deliveries for construction works in collaboration with construction sector players via the Svenska Byggbranschens Utvecklingsfond (SBUF, Swedish National Construction Industry R&D Organisation) (OpenBIM, 2013).

Therefore, international experience shows that: (i) industry takes action when the government demonstrates clear leadership; (ii) a national strategy facilitates the adoption of new information technologies such as BIM; and (iii) collaboration with industry is required to implement this strategy.

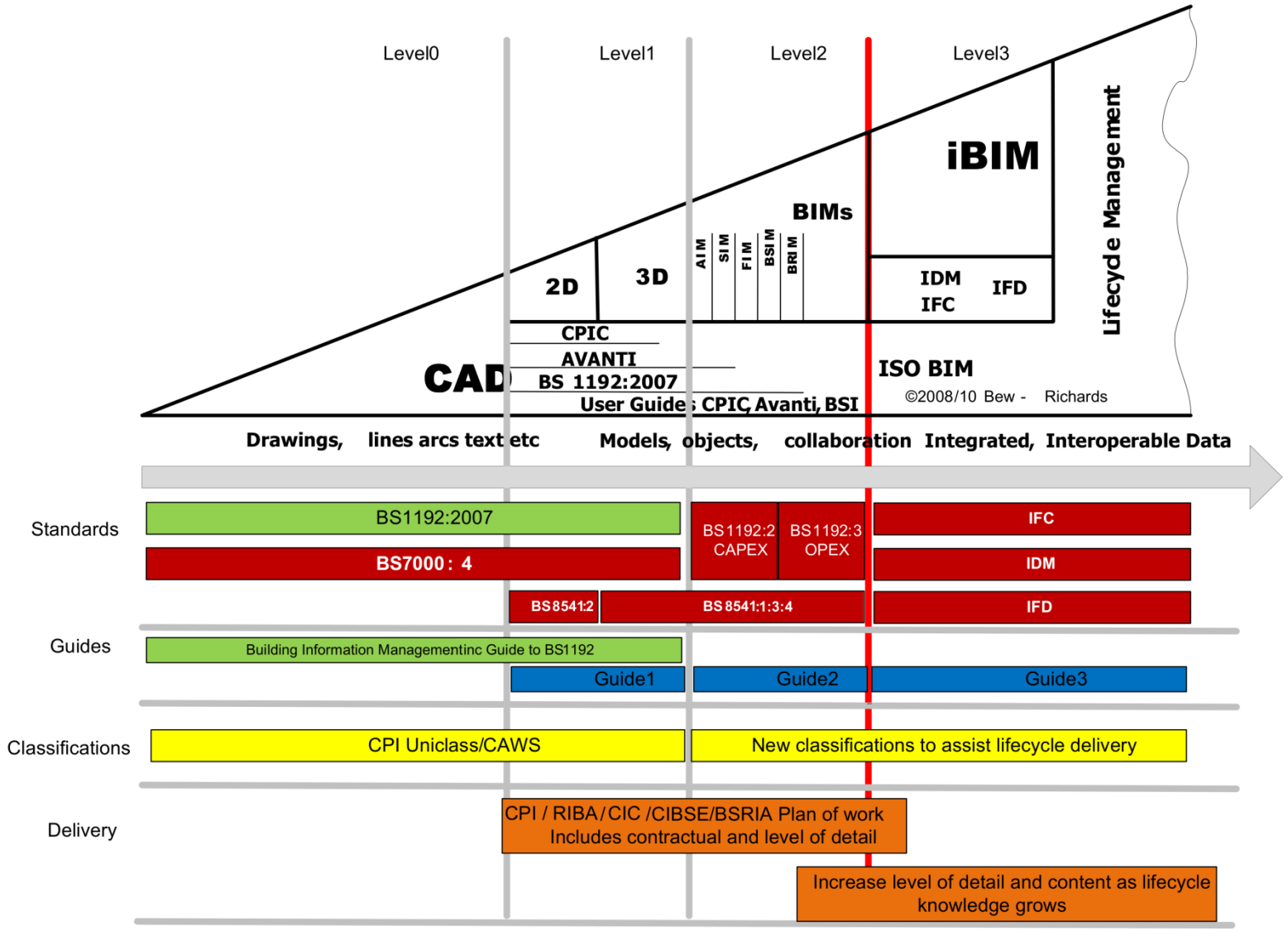


Figure 1. BIS BIM roadmap for the UK (BIM Industry Working Group, 2011).

4. Research Approach

This report presents an analysis of findings from: (i) desk top research undertaken in 2013/2014; and (ii) 21 interviews carried out in late 2013 (September – November) by SBEnrc researchers of a cross-section of the industry, including: clients, asset owners and procurement managers; design BIM managers; contractor project managers; supply chain, technical and industry experts; and representatives of industry-based associations. These industry professionals have an average 10-20 years working in the construction industry in Australia and Sweden and represented small and medium size enterprises (SME) as well as large organisations.

Sweden was chosen for this research given it is similar to Australia in that both countries have relatively small populations, similar levels of economic development (both are industrialised economies), democratic political systems and a relatively high degree of dependence on natural resources (Parker, 2007). However, the Swedish Transport Administration as a large powerful public infrastructure agency has developed a national strategy for the implementation of integrated project environments such as BIM based on the firm believe that this will pave the way for their future competitiveness and higher productivity (Trafikverket, 2013c).

This report focuses on those findings that relate to the creation and development of a national strategy for Australia, and how this was achieved in Sweden. It is contextualised using information found in academic and industry reports.

5. Activity in Australia – A Brief Insight

Australia is experiencing an era of activity and enquiry around BIM and integrated models for delivery throughout the construction industry. This includes:

- Joint Australian Construction Industry Forum (ACIF) and Australian Procurement and Construction Council (APCC) work including: *Creating Added Value from Construction: The case for project team integration* (2012); and the *Project Team Integration Workbook* (2014).
- ACIF's (2014) Policy Compendium publication in which they state: *ACIF believes that government, as a major client, has a responsibility to provide policy leadership in the adoption of new technologies and private sectors must coordinate the adoption of new technologies such as Building Information Modelling (BIM) in an orderly and consistent fashion*.
- buildingSMART initiatives including the 2012 *National Building Information Modelling Initiative* and their reports to the Department of Industry, Innovation, Science, Research and Tertiary Education on strategy (Mitchell, Plume, Tait, Scuderi, & Eastley, 2012).
- SBEnrc projects including the National BIM Guidelines for Infrastructure currently under development in the context of SBEnrc Project 3.28 (SBEnrc, 2014).
- Standards Australia activity including a review of *General Conditions of Contract* and considerations about a *BIM Addenda*. Published papers include: *The Economic Benefits of Standardisation* (2013); and *the Value in Governance of Information Technology* (2012).
- The Australian Department of Infrastructure and Regional Development (2014) report *Trends Infrastructure and Transport to 2030* in which they state that: *Smart infrastructure in the form of digital technologies will provide opportunities to improve productivity and contribute to sustainability* (Department of Infrastructure and Regional Development, 2014).
- NATSPEC has: (i) developed an on-line BIM Portal (NATSPEC, 2013); (ii) the *National BIM Guide* (2011) to *assist clients, consultants and stakeholders to clarify their BIM requirements*

in a nationally consistent manner (this document includes *Project BIM Brief* for defining and documenting the specific requirements of your project; and a *BIM Object/Element Matrix* which can be used as a reference or to define the properties and Level of Development of many of a project's building elements); and (iii) created a repository of Australian R&D projects currently being developed around BIM (NATSPEC, 2014).

- The *Australian Government Productivity Commission* report (2014a) makes some specific recommendations in this area including:
    - *The 'early contractor involvement model' should be trialled to test the costs and benefits of applying past contract performance by tenderers as a means of constructor selection, consistent with the practices of some private sector clients.*
    - *For complex infrastructure projects, government clients should provide concept designs using Building Information Modelling (BIM) to help lower bid costs, and require tender designs to be submitted using BIM to reduce overall costs. Governments should give serious consideration to where in their better practice guides they may specify the use of BIM.*
- Austroads, ARRB and APCC co-sponsored the *Building and Construction Procurement Guide – Principles and Options* which highlights the use of BIM for high-performing teams and an increasing trend towards more collaborative models observed across Australia (Casey & Bamford, 2013).

One of the key findings from the RATAS Program in Finland has been that one central issue to achieve a national approach and roadmap *is to reach a common understanding of main priorities for R&D and standardization among the central stakeholders in the industry* (Björk, 2009).

The Australian interviews pointed to the fact that there is a different focus for strategy between industry and public sector. The industry seems to still be working to establish their own business strategy while the public sector sees opportunities to develop strategy which can influence the industry more broadly. The incremental learning approach was also reflected in comments with regards to pilot projects, where small steps are taken and built upon to develop expertise, skills and confidence in benefits.

6. The Swedish Industry

> *Sweden is known to be strong in a number of technologies related to the built environment such as BIM application in construction projects. Firms in the built environment industry have since long ago relied on open innovation. Open interaction between firms is often aimed at stabilising accepted practice or developing it as an industry standard. This applies in particular to BIM as a support for virtual design and construction, where many parties are involved and need to change their practices simultaneously.*
>
> (Bygginnovationen, 2013)

As in Australia's construction industry, Swedish SMEs occupy a prominent position in government development and funding programs (Kadefors & Bröchner, 2014). This is probably due to the fact that in 2008 only 2% of Swedish construction companies had 50 or more employees and these represented only one third of the total share of the Swedish market (OECD, 2008).

In Sweden, we see [migrating to BIM] as a way of surviving, and also to ensure that future competence flow back to us… Making sure that the competence is still there in fifteen years, ten years, five years' time

Swedish Contractor

Sweden has recently carried out a deregulation process where functional specifications are being commonly used by clients instead of traditional regulation. This process has led Sweden's two largest contractors, Skanska and NCC, to prioritise the procurement of technically qualified and experienced staff. This strategy has ultimately led to the formation of strong and close relationship between the industry and Sweden's knowledge brokers and providers (Miozzo & Dewick, 2004).

In 2012, McKinsey Sweden identified:

> *One further example for achieving improvements and productivity gains could be to compare productivity in public-sector construction and infrastructure. The public sector accounts for a large volume of construction and infrastructure projects (the Transport Administration, Stockholm Transport, the county councils, traffic offices at municipalities), but there are no general comparisons of productivity. The Transport Administration and the National Audit Office are working intensively to devise a better way to follow up productivity gains in infrastructure (investments and maintenance), and many other government agencies and organizations should be able to benefit from the lessons drawn therefrom.*

(McKinsey Sweden, 2012)

The Swedish Government, as the largest infrastructure client, is currently using BIM to design and build large and complex projects, such as the Stockholm Bypass and the new City Line in Stockholm (WSP, 2013). Trafikverket has stated that they thereby expect to achieve significant financial and time savings by avoiding project planning issues that would otherwise only be detected at the construction phase, reducing the number of audits and time needed, and using sections of the tender documents as models (Trafikverket, 2013b).

[Trafikverket] *plans to use BIM on bigger projects, as pilots, because they have the power and we can work with it with industry. Then we go into smaller projects afterwards*

Swedish Client

Trafikverket has also adopted a series of four major pilot projects for the implementation of BIM/VDC, aligned with the European Union's V-Con initiatives, to benefit from the productivity gains of such implementation (Rijkswaterstaat, 2012).

The Swedish interviews showed that Trafikverket's strategy places an important focus on these four large scale BIM pilot projects. The interviewees highlighted the need for a broad focus, beyond

technical capabilities. Both public and private sector interviewees discussed research in the context of strategy development and while the private sector companies interviewed are developing their own internal BIM capabilities and strategies, alignment with their public sector clients was also a central consideration.

7. Lead Agent Role

The ability of information technology to transform organisations and entire industries[1] is widely accepted in the context of a change in industry boundaries, a change in industry structure, and/or a change on the basis of competition. This relationship between new technology and the institutional environment is important because implementation may require changes to standards and agreements which can in turn affect the economic performance of the industry (Crowston & Myers, 2004).

While collaborative decision making and multi-actor engagement is generally necessary to achieve transformation, it is also necessary to have a steering agent responsible for providing the overall guidelines and frameworks for operation of an industry sector. This ensures a common communication platform around performance and productivity associated with technology uptake.

The purchaser, that is the client, is the key driver for these things and procurement is the key driver of change

Australian Contractor

Whilst any actor involved in the network could take this role, public authorities are already in an empowered position (Hovik & Vabo, 2005) through facilitating, shaping and directing particular forms of management in accordance with specific rules, procedures and standards. Public agencies can reduce tensions, empower particular actors and lower the transaction costs across the supply chain by providing different kinds of *material and immaterial inputs* and resources (Sørensen & Torfing, 2009).

It has also been noted in previous case studies of meta-governance[2] by public authorities that industry network members believe that centrally designed rules help to facilitate and structure the local policy interactions as long as the central and regional objectives are broad enough to permit local adjustments and amendments (Damgaard & Torfing, 2010). Public agencies also have the power to promote access to a range of skills, and can help develop the capacity to learn through collaborative networks, technology diffusion and providing the conditions for organisational change to occur at the firm level (OECD, 1996).

In the UK for example, the government has taken a clear leading role in the adoption of BIM, in close collaboration with industry peak bodies. They used procurement tools to facilitate a timetable for

[1] Industry being not only suppliers and clients but also the regulatory framework and industry associations which form the institutional environment (Crowston & Myers, 2004).

[2] Meta-governance refers to the need of formal public organisations to exercise some control over devolved and decentralised decision-making organisations (Badie, Berg-Schlosser, & Mo, 2011).

SMEs and larger firms to adopt BIM as the technology of choice in design, construction and materials manufacturing (BEIIC, 2012). Melville (2008) provided some useful insight into the context for partnership arrangements between governments and the community services sector in both the UK and Australia.

> *The United Kingdom has a unicameral system of government in which local government plays a key role in social and personal social services... Australia has a three-tiered system of government. This in turn has considerable impact on how agreements or relationships between government and the sector are played out… In addition, the complex relationship between the federal and state levels of government arising from our unique form of federalism, also impacts on the sector. Although the federal government plays a role in policy development, the vast bulk of personal and social services are provided by the state governments.*
>
> (Melville, 2008)

The UK Government has put in place a programme to require collaborative 3D BIM (with all project and asset information, documentation and data being electronic) on its projects by 2016 (UK Cabinet Office, 2011). Essentially they have embarked, with industry, on a four year programme for sector modernisation with the key objective of reducing capital cost and the carbon burden from the construction and operation of the built environment by 20% (Masterspec, 2012).

In Australia there has been no attempt by the Commonwealth Government to embark in a national partnership agreements, limiting the possibilities for a traditional peak body to act as a lead agent for the implementation of BIM/VDC. However, non-standard peak bodies exist which could take this lead role. Either a public government meta-governor, such as the Transport and Infrastructure Council, or a completely new entity could reverse the trend of functional fragmentation identified in the Australian construction sector by the ACEA (2008) which inhibits the effectiveness of engineering project delivery and uptake of BIM/VDC.

In Australia there are a number of organisations with different roles affecting the uptake of BIM and new information technology. However, there are no umbrella organisation coordinating efforts across the nation that would lead to a harmonized implementation of BIM/VDC in infrastructure construction. Furthermore, there is no coordination or connection between design manuals and minimum standards across agencies. Based on the interviews, it is considered that either Commonwealth Government or a body composed of all the state and territory transport infrastructure agencies and industry, is in the best position to address this need and provide direction and consistency across state boundaries.

Mitchell, et al. (2012) also highlighted the *need for industry and Australian Government to take a lead position in implementing a standard approach to BIM implementation on asset portfolios*. They emphasised that by collaborating and participating in international activities, Australia can reduce the transaction cost associated with the transition.

As in the UK, in Sweden public clients such as Trafikverket have taken a clear lead agent role. The interviews showed that, international competition is leading to a collaborative national approach in the implementation of BIM/VDC (from other countries such as Germany, France and Poland). Balancing this however is the lead role taken by contractors and consultants in developing their own standards within the context of BIM/VDC project deliverables, and actively participating in research in this field. Contractors and designers expressed their desire and support to Trafikverket taking responsibility for the model quality and develop appropriate standards with industry.

8. Client Role

In Australia the key clients for the delivery of road and rail infrastructure are primarily the various State government agencies including New South Wales Roads and Maritime Services (NSW RMS), Queensland Transport and Main Roads (QTMR), and Main Roads Western Australia (MRWA). These agencies are three of the four largest road construction clients in Australia, contributing to 84% of the almost AUD7 billion invested by the State/Territories governments in the roads sector in 2012 and are currently responsible for almost 70% of the roads in the country in road length (Sanchez, Lehtiranta, Hampson, & Kenley, 2013). Each of these agencies has their own defined standards and forms of contracts.

In Sweden, the central Swedish Transport Administration (Trafikverket) is the primary client for the delivery and maintenance of road and rail infrastructure. The road network includes 98,400 km of state roads; 41,000 km of municipal streets and roads; and 76,100 km of private roads. The railway network includes 11,900 km of railway line, 90% of which is electrified (Malm, 2012). This agency develops long-term plans for the transport systems on road, railway, sea and flight (Trafikverket, 2013a) and is now using BIM to design and build large and complex infrastructure projects (e.g. Stockholm Bypass and the new City Line in Stockholm) (WSP Group Limited, 2013). They have also invested heavily in the implementation of BIM for rail projects (Stenkumla-Dunsjö developed in collaboration with WSP, construction is planned to begin in 2015 (Nilsson, 2011).

Trafikverket developed the legal guidelines on the digital delivery of construction works in collaboration with construction sector players via the Svenska Byggbranschens Utvecklingsfond (SBUF, Swedish national construction industry R&D organisation) (OpenBIM, 2013).

Clients need to understand what they want and set certain boundaries before they bring contractors on board

Australian Designer

The Australian interviews clearly identified the leadership role that can be potentially played by clients. Clients themselves also recognised the importance of their role in facilitating greater productivity through the use of data associated with BIM/VDC. Additionally, both clients and suppliers highlighted the importance of having informed and involved clients that know exactly what they need in order to capitalise on the potential benefits from using BIM and IPD.

In Sweden, the need for clients to specify functionality was a key issue, and also for the provision of different types of contracts to reflect these new requirements. There was acknowledgement of the emerging lead role of Trafikverket, built on past initiatives of industry.

9. Mandates

> *BIM mandates by US, UK and other government entities demonstrate how enlightened owners can set specific targets and empower design and construction companies to leverage BIM technologies to meet and exceed those goals, also driving BIM into the broader project ecosystem in the process.*
>
> (McGraw Hill Construction, 2014a)

The UK Government mandated *that public sector centrally procured construction projects will be delivered using BIM by 2016*. This has been supported by programs developed and led by the Construction Industry Council (CIC) (HM Government, 2012).

In Sweden although the government has not officially mandated BIM, it has asked their agencies to raise their productivity which has led Trafikverket to require BIM from 2015 (Trafikverket, 2013c). Figure 2 provides a rough timeline of the events that led Trafikverket to implement BIM. They have been supported by European Union through V-CON (Rijkswaterstaa) and nationally through their links to industry through peak bodies such as the OpenBIM, now BIM Alliance (BIM Alliance, 2014b).

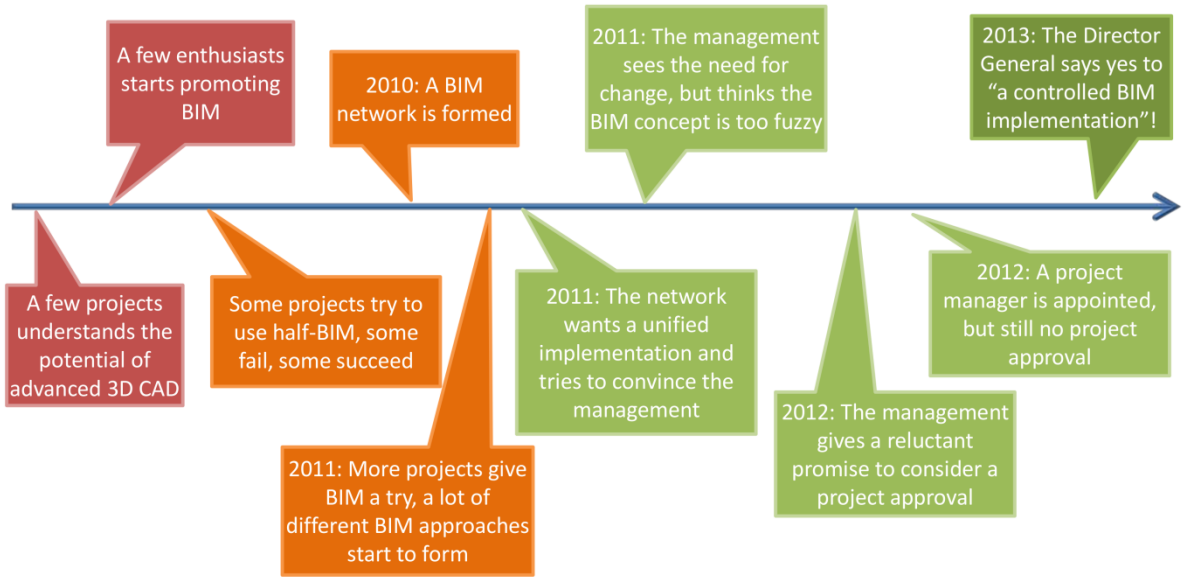


Figure 2. Rough timeline for Trafikverket BIM mandate (Albertsson & Nordqvist, 2013).

This shows that although a mandate by the central government can promote the accelerated uptake of new technologies, there are other ways in which public clients can take a leadership role. It should also be highlighted that in both cases the government agencies have the support of industry peak bodies which provide a forum for stakeholders and services that back the government actions.

There's got to be some, I don't like using the word mandate, but there's got to be some level of impetus for it… it can be as I said just half a dozen projects over the next three years spread across four agencies'

Australian Industry Expert

The Australian interviews showed that there seems to be little demand for a formal mandate without a period of testing and piloting the use of BIM/VDC. It was however acknowledged that a mandate from a single government agency could lead the industry as a whole towards a higher uptake of BIM/VDC and the realisation of significant benefits from more integrated systems.

The Australian Productivity Commission recently issued the following statement in their infrastructure industry report:

> *For complex infrastructure projects, government clients should provide concept designs using Building Information Modelling (BIM) to help lower bid costs, and require tender designs to be submitted using BIM to reduce overall costs. Governments should give serious consideration to where in their better practice guides they may specify the use of BIM.*
>
> (Australian Government Productivity Commission, 2014a)

This could be seen as a first step towards an informal mandate, depending on how these recommendations are received by the states and territories. In fact, some of the interviewees believed that a mandate would not have the same effect in Australia as it had in the UK because of the three-tiered government structure but that an agreement between the different transport agencies for coordinated action would be more effective.

10.Pilots

Pilot projects can be used to validate and demonstrate the readiness of the outputs. Exemplar projects can help increase acceptance and accelerate the uptake of well-designed collaborative BIM processes (Mitchell, Plume, Tait, Scuderi, & Eastley, 2012).

> *If the clients are keen for industry to grab it and run with it then they need… to identify some pilot projects where they work with the delivery team to implement this on a real job or a pilot job… if that goes well then they can have an information sharing forum or session with industry to say "look, we've piloted this and we're keen to extend the pilot program to a wider group of projects and gradually apply it to more and more of their jobs*
>
> **Australian Contractor**

The Finnish *Senate* (property services agency) has carried out a number of pilot projects using BIM since 2001. The exercise was so successful that in 2007 it required the use of IFC models on all its projects. Similarly, the Norwegian Defence Estates Agency carried out a series of three pilot projects (2007-2009) which led to a mandate in 2010 (BIM Industry Working Group, 2011).

The UK Government has established a program of pilot projects as a way of collecting and assessing data. They see this effort as a way of assisting *both Government and businesses in understanding and developing ways to improve the construction, operation and management of assets and take better decisions at each stage of future projects* (HM Government, 2012).

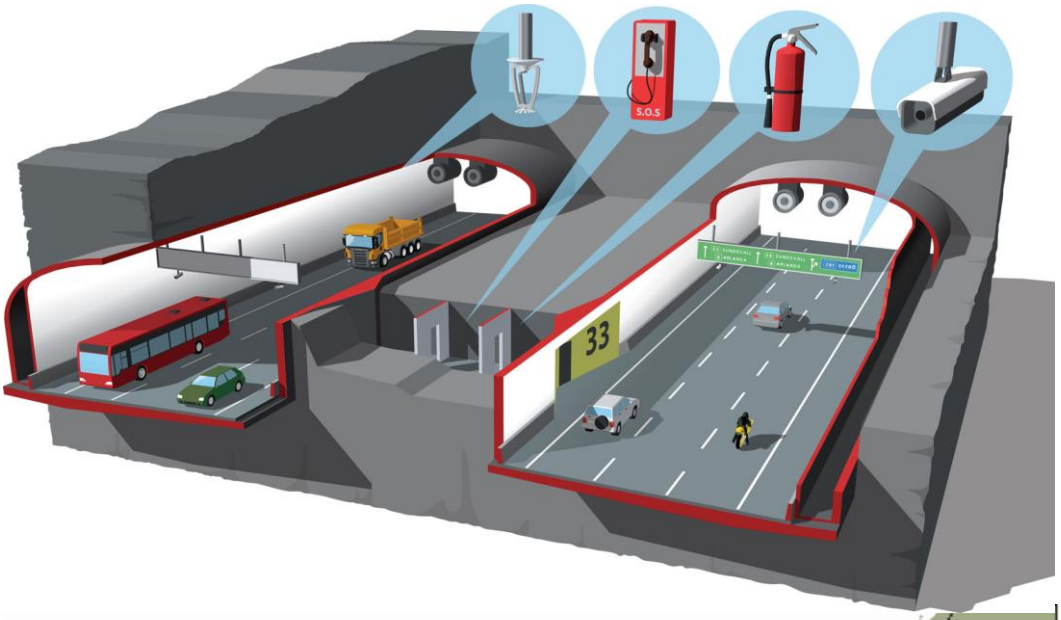
> *The clients need to know that they are still getting value for money and… that they're not restricting competitiveness… that's a learning process and… a project to validate that the BIM process provides the necessary gains and efficiencies and productivities that they're looking for. I have no doubt that in the fullness of time that can be proved. It's the initial impetus… that needs to be put in place and identifying a feature project to start that going*
>
> **Australian Contractor**

Trafikverket has established four large pilot projects currently being undertaken in Sweden including the *West Link* project in Gothenburg (rail tunnel, SEK20 billion), the *Hallandsås* project (rail tunnel, SEK10.8 billion), the *Stockholm Bypass* (21km motorway link including 18km tunnel, SEK27,6 billion) and the *Mälaren line* (railway line expansion, SEK10.7 billion) (Malm, 2012).

Trafikverket is also part of the EU funded *Virtual Construction for Roads (V-Con)* initiative which aims *to improve the efficiency and effectiveness of the National Road Authorities by improving data exchange in the civil infrastructure sector* (Rijkswaterstaa). V-Con will use the Stockholm Bypass as a reference project (Rijkswaterstaat, 2012) to inform the two project parts: (i) development/ standardisation; and (ii) Pre-Commercial Procurement (PCP) (Rijkswaterstaa).

Get the schema first, get the cycle going and get some learnings out of it and then we can say "okay we've proved this. It works and these are the things we need to do to get it to work"

Australian Client



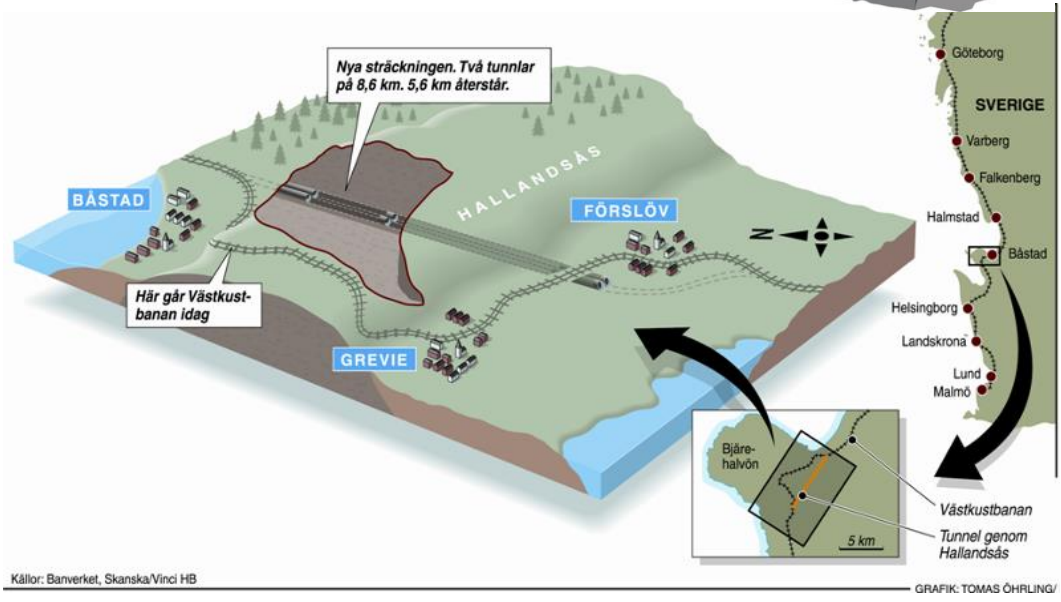


Figure 3. Pilot Project Sweden - Stockholm Bypass project (top) & Hallandsås project (bottom) (Malm, 2012).

Interview results showed that there is an incremental approach to implementation through testing activities on pilot projects being undertaken in Australia by some agencies. This incremental approach to BIM uptake was the subject of a case study in 2012/13 of the implementation of digital modelling in buildings in the Queensland Department of Public Works (Kraatz & Hampson, 2013).

Most Australian interviewees highlighted that pilot projects are an important factor in increasing acceptance of new technologies and ways of working. Contractors, designers and client alike explained that pilot projects help to understand implementation issues as well as quantify benefits. Some of the interviewees also mentioned that pilot projects can be used as learning tools by disseminating the outcomes and learned lessons.

In Sweden, pilot projects are being used both as exemplars for the industry and as internal learning tools to develop/finalise internal procedures, technical tools and standards.

11. Metrics

Although BIM and more integrated models promise many benefits, there are few metrics that can objectively measure and quantify the productivity improvement and other intangible benefits.

> *Without such metrics, teams and organizations are unable to consistently measure their own successes and/or failures. Performance metrics enable teams and organizations to assess their own competencies in using BIM and, potentially, to benchmark their progress against that of other practitioners. Furthermore, robust sets of BIM metrics lay the foundations for formal certification systems, which could be used by those procuring construction projects to pre-select BIM service providers*
>
> (Succar, Sher, & Williams, 2012)

The benefits and failures of BIM need to be measured throughout the lifecycle of the project to guarantee a continual improvement process (Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013) and support the adoption by new users who depend on how the real benefits of the transition are perceived (Lu, Peng, Shen, & Li, 2012).

The development of objective metrics to systematically measure improved performance are essential to a more efficient industry that allows projects to be benchmarked against similar projects *to identify standards in the national performance of the construction industry and identify areas for improvement* (Eadie, Browne, Odeyinka, McKeown, & McNiff, 2013).

Succar, et al. (2012) explain that developing metrics is as important as ensuring that the developed metrics are*: accurate; applicable; attainable; consistent; cumulative; flexible; informative; neutral; specific; universal;* and above all *usable (Intuitive and able to be easily employed).*

The lack of agreed and readily available metrics for assessing the benefits of BIM/VDC implementation was largely acknowledged by the interviewees and is commonly mentioned as an issue to make the business case for BIM/VDC.

In Sweden it's actually very hard to find proper metrics of the value of BIM.

Swedish Contractor

McGraw Hill have released a series of SmartMarket Reports on the value of BIM, its global uptake and associated metrics since 2008 McGraw Hill (2008; 2009). They recently released *The Business Value of BIM in Australia and New Zealand* (McGraw Hill Construction, 2014b), and this provides some valuable documentation on the level of use, and return on investment for BIM use in this country. However, this report only covers designers and contractors, and does not include clients who as shown in the US (Gallaher, O'Connor, Dettebarn, & Gilday, 2004) stand to gain the most from implementation through whole-of-life asset management. Even so, it highlights that 2/3 of the surveyed industry is developing and implementing metrics to monitor their ROI, such as process-related metrics (e.g., fewer RFIs and unplanned changes); project schedule metrics (e.g., faster project delivery); and financial metrics (e.g., reduced cost, higher profitability and productivity) (McGraw Hill Construction, 2014b). This has led to the identification of the top benefits and ROI shown in Figure 4.

Benefit	Architects/ Engineers	Contractors
Reduced Errors and Omissions	50%	38%
Overall Enhancement of Your Firm's Image as an Industry Leader	36%	43%
Reducing Rework	31%	28%
Ability to Work Collaboratively With Owners or Design Firms	27%	24%
Offering New Services	24%	14%

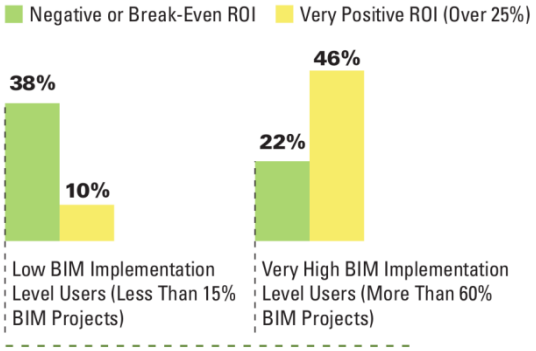


Figure 4. Top five BIM benefits received by architects/engineers and contractors (percentage receiving the benefit at a high or very high level (left); Impact of BIM implementation level on ROI (Right) (McGraw Hill Construction, 2014b)

In terms of metrics for the infrastructure industry specifically and including clients, the McGraw-Hill (2012) global report explores this issue further. However, only 13% of the respondents reported working in the transport infrastructure industry and "other". Therefore, it seems there is a lack of surveys that cover those metrics used by the transport infrastructure industry across the supply chain.

Publically available information of this kind is an important element in demonstrating the medium to long-term benefits of adoption of digital modelling. While firms do establish and report on internal KPIs such as those to monitor time-savings, return on investment, error reduction, there is no national or global standard for the gathering and reporting of such data which is then made available more broadly to enable policy settings and drivers to be set in place.

The *Document Review Research Report 2*, prepared as a part of this research highlights discussed metrics. The following extracts provide an overview of this discussion. Full referencing of material is provided in that document.

- QTMR's stresses the importance of *outcome/overall performance metrics* by highlighting that if the brief inadequately defines clear performance, technical and quality criteria, there is the risk of project failure. Objectives for durability, design life, operational criteria, standards of finish and aesthetics, community and environmental standards should be defined.
- NSW RMS makes use of the contract program prepared by the contractor to address these issues. Financial bonus clauses, such as NSW RMS' innovation clause, tied to success criteria based on these metrics, can be further used motivate participants.
- MRWA requests that their contractors perform in accordance with probity requirements, terms of contract and current best practices.
- NATSPEC recommends that organisations integrate their data management throughout the supply chain, so the BIM outcomes (as-built) and metrics are aligned with the requirements of facility and asset managers.
- The AIA recommends that current approaches to defining performance metrics can remain unchanged for any activity which is traditionally performed. However, if the goals and metrics are defined collectively, this can provide ownership and motivate participants to perform better.
- CIOB uses the Design Execution Plan to define performance specifications including duration and milestones for each LOD.
- AEC (UK) recommends the use of BIM-specific metrics to be addressed in the Project BIM Execution Plan.

In the context of *the Document Review Report*, the use of BIM has been found to be beneficial for this process by providing a common access database where KPIs can be recorded and reviewed by all participants, potentially motivating them to increase their scores.

In Australia, interviewees made limited comment regarding metrics as such, likely due to the early stages of implementation in Australia. However, a few of the interviews did mention that there is a need to proof and quantify the value of BIM.

> *We'll see increases in productivity that need to be measured across several projects… it's very hard to determine what the measures might be on a single project evaluation*
>
> **Swedish Industry Expert**

In Sweden the use of BIM is relatively more mature than in Australia. Nevertheless, the interviews showed that there is also an apparent lack of formal metrics. Although there is an intuitive value added through higher productivity, process improvement and better communications, the industry is still developing objective methods to measure and monitor these benefits.

12. Standards

> *Mark Bew who chairs the HM Government BIM Task Group and led the creation of the BIS BIM report said: "Standards play an important role in ensuring the wider adoption of BIM technologies, processes and collaboration by ensuring that the same accurate data can be accessed throughout the supply chain.*
>
> (BSI, 2013)

Standards Australia (2013) further highlights the importance of standards at the macro-economic level and their direct relationship to productivity through: (i) safety; (ii) international competitiveness and trade; (iii) interoperability of technologies and processes; and (iv) reduction of information asymmetry. This report also emphasises the role of standards in facilitating the diffusion of new technologies throughout the industry (Standards Australia, 2013).

Gu and London (2010) explain that standard processes and protocols are key to assigning responsibilities and conducting design reviews and validation. Also standard data-exchange formats and a standard vocabulary are needed to increase consistency between projects and software platforms.

> *Good standards provide clear requirements that set minimum conformity specifications and strike the right balance between too many and too few varieties; this works in the best interests of both the product supplier and the consumer… standards serve many purposes. They enable trade, improve safety, facilitate efficient use of resources, reduce time, improve quality, permit compatibility and aid integration. Businesses and consumers benefit from them the world over.*
>
> (National Building Specification (NBS), 2014)

A recent survey carried out by the NBS in the UK showed that only 24% *agreed that the current level of standardisation is right.* This would suggest that a greater degree of standardisation is needed to ensure the successful adoption of BIM. This gains even more relevance when placed in a context of increasing globalisation and international design service providers. Common standards and processes allow higher levels of collaboration across international borders (National Building Specification (NBS), 2014).

Standards Australia would work to develop some standards … You've got to learn from the US experience; it's exactly what they have done … [it needs to be done by] *a very cross functional committee; bring in engineers, technology guys, and somebody like a buildingSMART*

Australian Industry Expert

A recent report by Sharkey, et al. found that the majority of Australian contracts are based on standard forms and at least half of public infrastructure construction projects are done using standard forms (Sharkey, Bell, Jocic, & Marginean, 2014). Standards Australia is currently conducting a review and update of AS2124 General Conditions of Contract (GCC). This document is used by most Australian transport agencies (i.e. SA DPTI, QTMR, and Tasmanian Department of Infrastructure, Energy and Resources) or GCC variations based on it and is due to go to public review at the end of 2014. However, the review will focus on dispute management; extension of time, programming and early warning procedures; insurance; and security of payments legislation, PPSA and insolvency (Standards Australia, 2014). An opportunity may therefore exist for this organisation to facilitate the development of a BIM addendum to the current GCC, through their committee process.

There are several other activities underway in Australia that may result in a more standardised approach to BIM/VDC implementation. These include:

- The joint Australian Construction Industry Forum (ACIF) and Australian Procurement and Construction Council (APCC) *Integrated Project Team Workbook* (2014).
- buildingSMART initiatives including the 2012 *National Building Information Modelling Initiative.*
- SBEnrc National BIM Guidelines currently under development in the context of Project 3.28 (SBEnrc, 2014).
- NATSPEC have developed an on-line BIM Portal with various guides and aids (NATSPEC, 2013).

In Sweden, an overarching framework is provided from the European Commission through the Virtual Construction for Roads (V-Con) initiative, regarding standardisation and implementation of Building Information Modelling (BIM) technology in the roads sector.

> *The V-Con project aims to improve the efficiency and effectiveness of the National Road Authorities by improving data exchange in the civil infrastructure sector. BIM has already been successfully implemented in other sectors and is a worldwide development*
>
> (Rijkswaterstaa)

The consortium includes the Dutch Agency of the Ministry of Infrastructure & the Environment (Rijkswaterstaat) as the project leader, Trafikverket, CSTB (France) and TNO in the Netherlands. This group is defining standards, procuring software and launching a PCP for BIM server and software tooling (Rijkswaterstaa).

In Sweden Trafikverket is central to setting the standards for projects, given their significant market share in the delivery and maintenance of road and rail assets. However, contractors, designers and academics having actively involved in the development of these standards and OpenBIM has served as a forum for these discussions.

> *There are enormous benefits from having a much more consistent set of standards across Australia… so I would certainly strongly support the adoption of a national standard or Australian standard for this*
>
> **Australian Contractor**

In Australia, contractors and designers alike expressed frustration with the diversity of standards already in place between the different states and strongly support the development of national standards. Some mentioned that this hindered information sharing not only between industry sectors but even within the same organisation between different offices. Australian Standards was commonly identified as the peak body ideally suited to developed national standards if the individual states decided to adopt them.

The Australian Productivity Commission also highlighted the need for a coordinated approach to the establishment of technical standards around BIM. They recommend that this should be done in consultation with industry and other private sector procurers but spearheaded by Australian Government agencies. This would in turn *ensure that the greatest benefits from the adoption of BIM are realised* (Australian Government Productivity Commission, 2014b).

We share a lot of projects with our other office in a different state… and it's very frustrating to flop in between the two standards. So if there was one national standard that would be amazing

Australian Designer

The availability of national standards would avoid duplication across the industry and allow the use of libraries that would in turn reduce the cost burden of adoption and make the transition more accessible to small and medium-sized enterprises.

13. Mapping the Industry

For a national strategy to be developed and rolled out successfully it is necessary to first identify who the actors are in the network, what their role is and what impact they have on their sphere of influence.

The Australian term "peak body" includes non-for-profit umbrella organisations that *provide information dissemination services, membership support, coordination, advocacy and representation, and research and policy development services for its members and other interested parties.* This term is equivalent to intermediary bodies, federations or umbrella organisations in the UK and USA (Cheverton, 2005).

These organisations may also be defined as carrying out similar roles to that of System Integrators described by Winch (1998) having: (i) the skills to integrate interdependent components into a coherent whole; (ii) detailed knowledge of client requirements; and (iii) knowledge of the rules and regulations governing the industry.

The role of peak bodies must be studied in the context of the industrial relations system in which it functions and attention must therefore be paid to the different layers found in those relationships (Brigden, 2000).

The following sections focus on identifying and mapping those peak bodies that can influence the development and uptake of new standards and technologies in Australia's transport infrastructure construction industry.

The organisations were first identified by the interviewees and the list was later submitted to a group of industry experts for verification and validation. Sources of information used for the characterisation of each organisation were: organisation's websites; industry reports; strategy, operational and annual reports; and any other publicly available information. The research focused on identifying the role, processes, sphere of influence, and impact of the selected organisations as defined below. The detail methodology will be published in a peer-review academic journal paper.

13.1. Roles and Identity

In order to identify the role of umbrella organisations it is important to understand their identity: who they are, what is their purpose and objective and what do they want to be. ACTCOSS (2010) classifies peak bodies as policy development and advocacy; sector development; and membership. This classification is similar to that of Young (2001), where policy development and advocacy are polities, memberships are economies and sector development could be seen as a type of goal-

seeking system that only applies to community sector peaks. ACTCOSS (2010) therefore limits the definition of peaks to organisations that *fit between service providers and government.*

However, when analysing an industry sector where the most influential actor is likely to be the clients who are public organisations at different levels of government, such as the transport infrastructure construction industry, this definition limits the capacity to understand how different umbrella organisations interact with each other and the consequences of such interactions. It also does not include umbrella organisations which are formed by government entities. Thus, for the purpose of this research peak bodies are defined as: not-for-profit umbrella organisations that *provide information dissemination services, membership support, coordination, advocacy and representation, and research and policy development services for its members and other interested parties* (Cheverton, 2005).

This report makes use of the peak body's vision, objectives and organisational structure to classify them within the three identities defined by Young (2001):

(i) **Goal-seeking Systems**: There is a coordinated effort across the organisation to achieve common system-wide goals. These organisations rely on hierarchical authority and unified command and control.

(ii) **Economies**: The organisational goal is to meet the economic needs of their members more efficiently than in the open market. The organisation is an economic actor that aims to determine what services it can provide to its members for a fee. This is done through a negotiation process with their members and therefore relies on reciprocity and exchange among its participants.

(iii) **Polities**: The organisation is used as a forum for member organisations to meet and work towards a common position, strategy and collaborations. The purpose of these organisations is *to facilitate discussion and debate, to reach common understandings and strategies, and perhaps to manifest collective action on those strategies.* Therefore, such organisations rely on persuasion and consensus building (Young D. R., 2001).

Peak bodies can have multiple identities, for example Cheverton (2005) highlights that although most Australian peak bodies act as polities many also operate as economies. This means having a federation structure that represents diverse views and advocates for common consensus, but also provides their members with governance and service development support. This duality may *allow an organization to deal effectively with different constituencies that have different expectations of the organization* (Young D. R., 2001).

13.2. Process

This analysis focuses on understanding how these organisations choose, develop and disseminate new outputs in the form of standards, tools, methodologies, processes, guidelines, and other. Succar (2009) defines these outputs as deliverables which include: regulations, guidelines, standards, best practices, benchmarks, contractual agreements, and educational programmes.

13.3. Sphere of Influence

Levine (1972) highlights the difficulties of mapping and representing complex networks with diverse actors. The concept of sphere of influence is used to study the positioning and interrelations of organisations in their network. For the purpose of this report, the peak bodies will be studied in terms of their direct membership, collaborations with other organisations and other activities that may increase their sphere of influence and impact on the transport infrastructure construction industry.

13.4. Impact

This analysis aims to understand how organisations measure and monitor the impact of their outputs.

13.5. Role of Peak Bodies in Australia

Peak bodies *flourished in Australia in the 1970s and 1980s.* However, their impact and spheres of influences have been limited by a shrinking level of power since the 1990s made worse by forced amalgamation and de-funding. This has led to most peak bodies focusing on policy development and advocacy being identified as polities and economies (Cheverton, 2005).

As explained by Maddison & Denniss (2005) this reduction in the peak bodys' power to influence policy came about mainly due to the change in the government's discourse in relation to the role of these groups in Australia, observable since 1996.

Therefore, the power to generate change and the authority of peak bodies in Australia now *rests on the willingness of the affiliates to cede and abide by such levels of authority* brought by a balance between *power over* (so members follow the same vision) and *power for* (collective power to achieve collective interests) (Brigden, 2000).

Melville (2008) adds that Australia's three-tiered government system has a significant impact on the way agreements are reached and the role that not-for-profit organisations have. This is due to differences between state governments and the *complex relationship between the federal and state levels of government arising from our unique form of federalism.* This is probably part of the reasons behind Australia's history of division among this kind of organisations (Ellem & Shields, 1996).

Young (2001) also suggests that the type of peak body is related to the goal congruence among members, transaction cost and efficiency (i.e. *if congruence is high, the goal-seeking system (bureaucracy) minimizes transaction costs; if congruence is low, the economy (market) is efficient; if congruence is between these extremes, the polity (clan) is efficient).* The lack of purely goal-seeking systems in Australia's construction industry would suggest a lack of harmony between key players and a fragmented industry.

The construction industry has in fact been characterised across the globe as segmented in silos of interest, having little alignment of objectives between them and presenting significant duplication of effort (Jonassen, 2010). These traits have also been observed in Australia's construction industry (Hampson, Kraatz, & Sanchez, 2014) and are obviously reflected in the complex network of peak bodies observed in the peak body map.

13.6. Australian Infrastructure Governance

In Australia, the transport infrastructure sector represents nearly 5% of Australia's Gross Domestic Product (GDP) and provides over one million jobs across 165,000 companies. *It is a critical input to national productivity* (SCOTI, 2012b). The responsibility for planning, funding, constructing, maintaining and operating transport infrastructure is shared between the three levels of government (federal, state and local - Figure 5). This means that, although there is generally good collaboration between levels, the complex intergovernmental arrangements for transport infrastructure management create the potential for a number of issues (Newman, et al., 2012), contributing to a lack of national standard practices and strategies that could support the widespread uptake of IPD and BIM. This is reflected on the fact that the only goal-seeking system found is also a polity, where decisions made are based on consensus from all members.

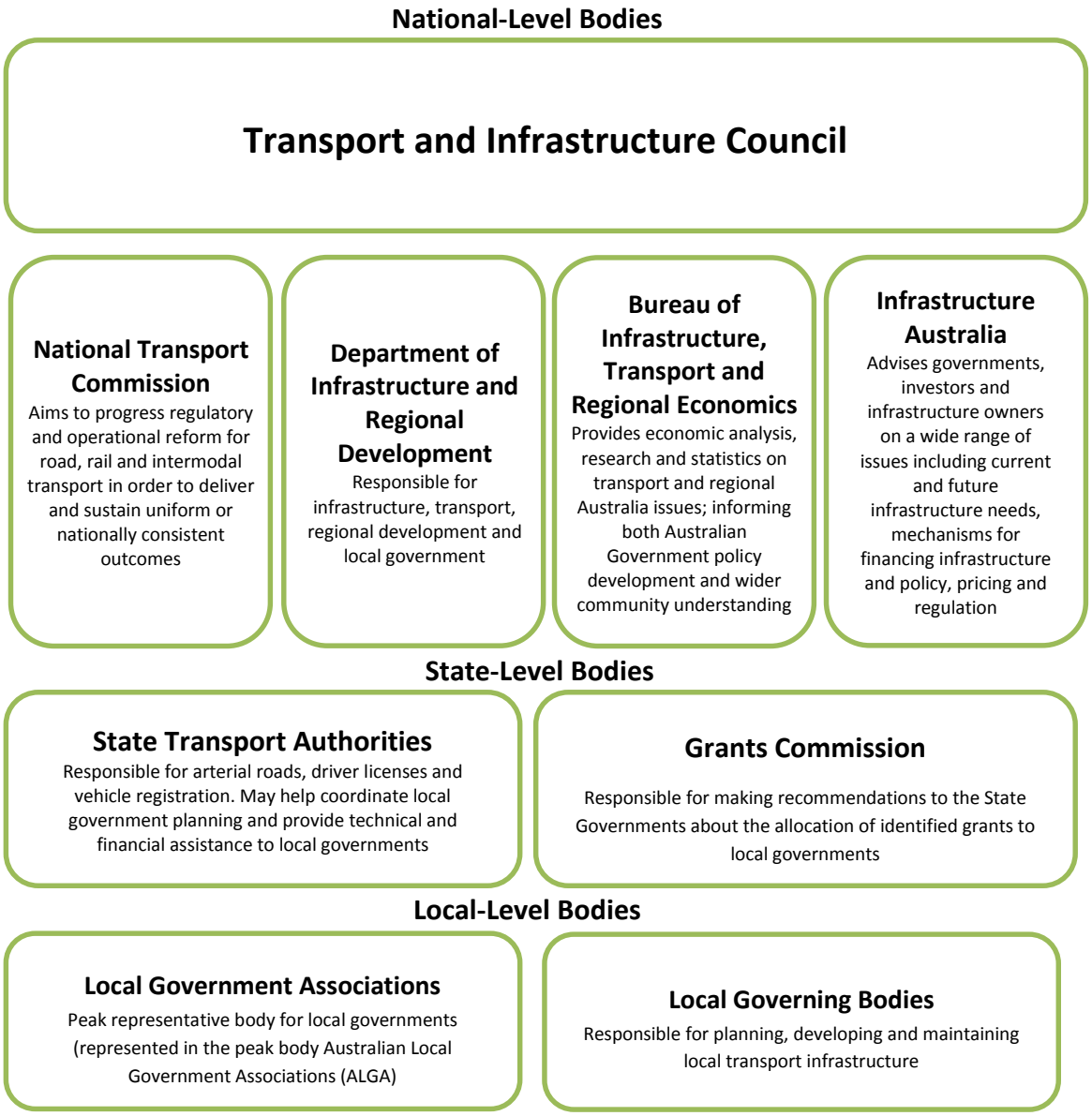
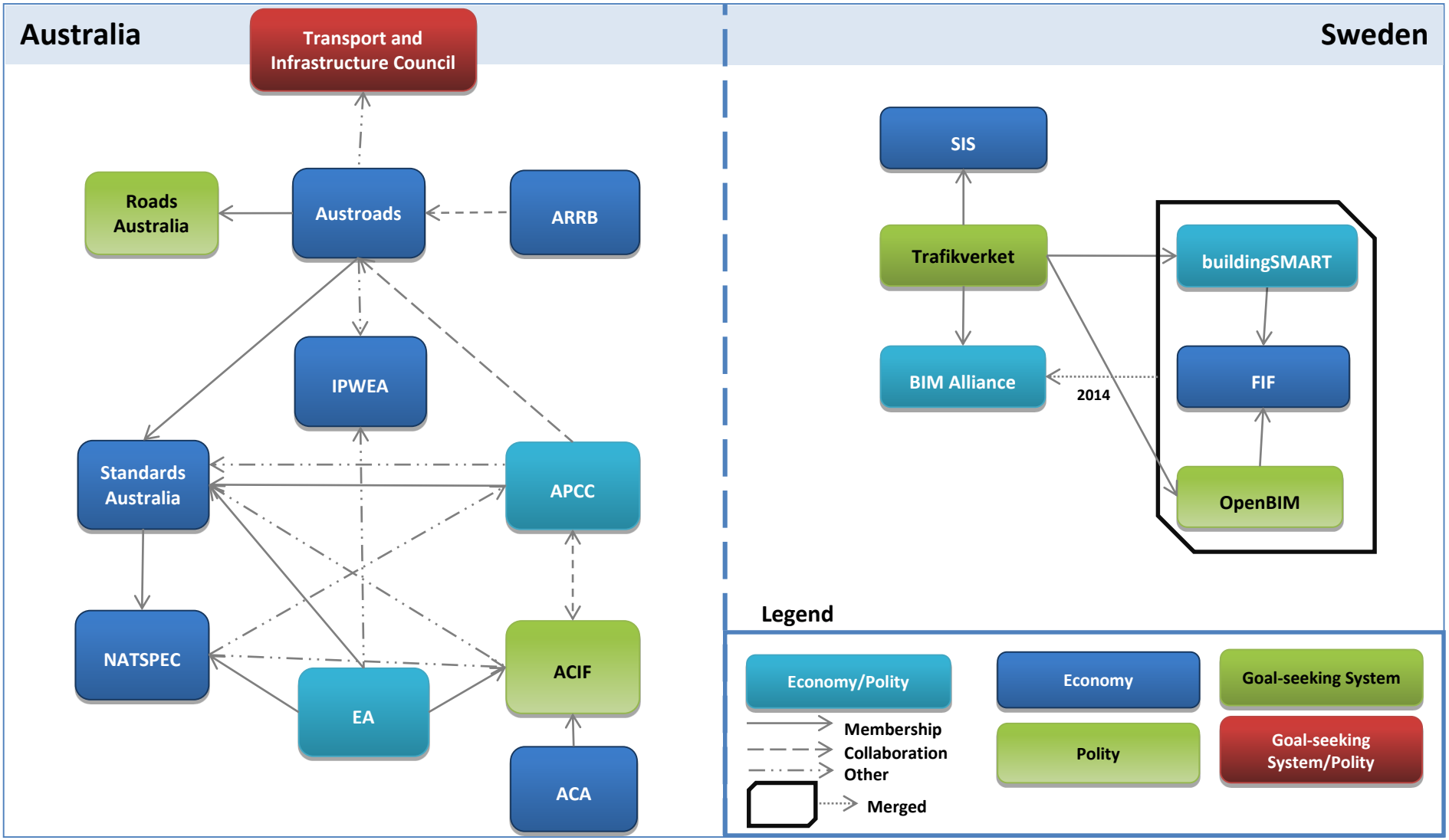


Figure 5. Australian bodies responsible for transport infrastructure within each level of governance based on The Allen Consulting Group, (2009), Australian Government (2013), Infrastructure Australia (2014) and ALGA (2014)

14. Australian and Swedish Peak Body Maps



Note: the direction of the arrows reflects the direction of the relationship and outputs. For example if the relation is membership, the peak body at the bottom of the arrow is a member of the peak body at the tip of the arrow. If the relationship is collaboration or other, the peak body at the bottom of the arrow provides input or other services to the peak at the tip of the arrow. A double-arrow reflects bilateral collaboration

15. Discussion

Australia's complex intergovernmental arrangements in transport infrastructure management are reflected by the fact that the only goal-seeking system found is also a polity. By way of contrast, Sweden has a single authority (Trafikverket) that, although it collaborates with local councils on specific matters, it also oversees all transport infrastructure management across the country (Trafikverket, 2011).

Another key difference found was the way the goal-seeking systems interact with the other peak bodies. In Australia the relationships between the mapped peak bodies vary between membership, collaborations or "*other"*, while in Sweden the interactions are mostly through membership. In Sweden, Trafikverket is actively involved in the output development carried out by other peaks through their membership. Trafikverket provides input and acts as reviewers with other industry organisations in the development of industry standards and guidelines. In Australia, some transport agencies are more involved than others in the production of outputs, making it more difficult to have all agencies agreeing to the uptake of certain output.

This lack of a two-way style of engagement in Australia might be partially due to a continued decline in the government investment in areas related to construction research (Barlow, 2012) and the style of governance. This would limit the availability of personnel that can be actively involved in programs such as Fi2[3] and OpenBIM in Sweden that led to the production of national standards, a more widespread use of BIM and probably helped create the BIM awareness that led to Trafikverket mandating the use of BIM in all investment projects from 2015 on.

In the UK, a concerted effort between government and umbrella organisations led to a series of legal, economic and operational reforms (Melville, 2008) that allowed intermediaries to *directly participate in policy development through systemic approaches with the policy process* (Strickland & Goodes, 2008). In Australia on the other hand, there has been no attempt by the federal government to embark in a national partnership agreement with this sector (Melville, 2008) limiting the possibilities for a traditional peak body to act as lead agents for the implementation of BIM. However, non-standard peak bodies such as the Transport and Infrastructure Council (T&I Council) have the capacity to drive this change supported by: (i) a forum provided by TISOC *for collaboration between the Australian, State and Territory and New Zealand Ministers and the Australian Local Government Association* (Australian Government Productivity Commission, 2014a); and (ii) the expertise provided by Austroads through their Memorandum of Understanding (Austroads, 2013).

Austroads is in a position to take a proactive, constructive and collaborative approach which has been so successful in other sectors at a state level (Melville & Perkins, 2003) and have a

[3] Fi2 is an open standard developed by Föreningen för Förvaltningsinformation (FIF, Association for Management Information), now commonly used in the real estate industry, which has been argued to possibly being a first step towards implementation of BIM in Facility Management (Hoof, 2011).

complementary role as partners to the government (Young D. R., 2000). Austroads currently undertakes activities for T&I Council on an ad-hoc basis (as allocated by TISOC or the Council).

> *Austroads is a very effective vehicle for encouraging collaboration across jurisdictions. The process of getting a project accepted onto the work plan, produced and cross-agency endorsed, is suitably rigorous for undertaking wide-ranging technical roads research and producing operational guidelines, but the arrangements are not as well suited to driving implementation or development of national reform, especially projects with shorter timeframes, which require strong top-down governance and change management arrangements.*
>
> (SCOTI, 2012b)

The Organisation for Economic Cooperation and Development (OECD) considers that Australia's chance of success against the economic challenges that have an inter-jurisdictional dimensions will depend crucially on coordinated actions by a number of agencies at state level and those at the Commonwealth level (OECD, 2010). TISOC is the national body that can and must serve as forum for state and territory transport agencies to reach an agreement in order to have a consistent and coordinated national strategy.

In the present research, many of the Australian interviewees mentioned the importance of carrying out pilot projects led by the transport agencies to test and showcase the value of IPD and BIM. Currently, several of the transport agencies represented in TISOC are planning or already implementing Integrating Project Teams (IPT) (MRWA) and BIM (NSW RMS and QLD) pilot projects to determine the business value of these models within the transport infrastructure industry. However, these efforts are carried out almost in isolation from other state and territory agencies. This represents a missed opportunity for leveraging on each other's resources and maximising them by collaborating and sharing lessons learned. If TISOC were to reach an agreement to start a coordinated national pilot program, each organisation could target better their use of resources and maximise their return on investment. This pilot program can be used to validate processes and should be accompanied by a resolution to develop a dissemination strategy to government, academia and industry (Mitchell, Plume, Tait, Scuderi, & Eastley, 2012).

Once TISOC has reached an agreement, it can request Austroads to collaborate with the industry and other peak bodies to develop standards and metrics to measure the value of IPD and BIM throughout the pilot projects. Having a set of standard performance indicators and processes to monitor the benefits of these models would allow cross-state comparisons. This would lead to better informed decision making and gap analysis for process improvement.

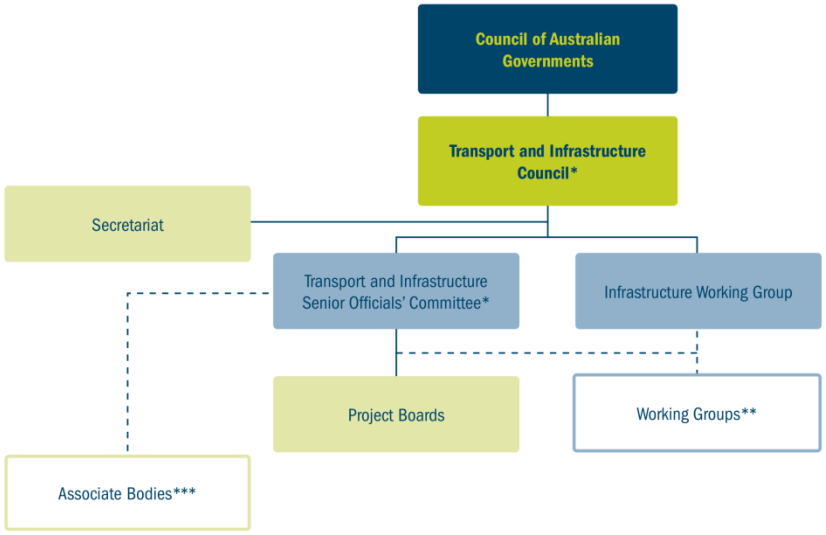
The Australian Sustainable Built Environment (SBEnrc) is working on developing such metrics in their new project 2.34 *Driving Whole-of-life Efficiencies through BIM and Procurement*. This project will end in September 2015 and aims to identify and assess the added value of the creation of industry benchmarks for implementing BIM in whole-of-life asset management, with a focus on procurement methods and efficiency gains for building and infrastructure. Outputs from this project will provide a base for public sector clients to improve their approach to implementing BIM and monitoring their progress towards fully integrated whole-of-life asset management systems. Austroads can therefore leverage on their relationship with SBEnrc and other organisations carrying out research in this are to provide the transport agencies with a single set of standard processes and metrics to monitor the pilot projects.

As shown in Figure 6, there are working groups that are created for a limited time to advise TISOC and the Council on matter specific to their priorities such as *infrastructure policy and investment, including road, rail and ports* (SCOTI, 2013). One of such working groups would then be formed to implement the processes and metrics recommended by Austroads-SBEnrc in the pilot projects and report their lessons learned to TISOC.

Strengthening and using appropriately the ties between public clients and industry organisations can help Australia move towards becoming a more highly advanced knowledge-based economy (Ofori, 2002). Based on the present research, this process can be most effective if a bi-directional line of communication is established between TISOC, through an inter-state working group, and Austroads. Thus, actively engaging all transport authorities in the development of outputs that would be submitted to the Council for discussion and approval.

Once TISOC has assessed the outcomes of the pilot program and reached an agreement on a policy framework for a nationally consistent approach to BIM, this group would provide recommendations to the Transport and Infrastructure Council for endorsement.

This approach has been proved effective in related areas. For example, the Transport and Infrastructure Council recently endorsed a policy framework to build Intelligent Transport Systems across Australia. These systems consist on the application of information and communication technologies to transport and are supported by the *Australian Government's National Urban Policy.* This policy *highlights the role that new technologies can play in improving and enhancing safety, efficiency, cost effectiveness and environmental performance of existing infrastructure networks, and reduce the need for costly new investment* (SCOTI, 2012a). They expect this policy framework to facilitate the involvement of industry and research organisations in a new market (SCOTI, 2012a). A similar policy framework developed and supported by the Transport and Infrastructure Council could produce similar outcomes for IPD and BIM.



* The National Transport Commission reports to either the Transport and Infrastructure Council or the Transport and Infrastructure Senior Official's Committee.
** Time Limited.
*** Road Safety Executive Group, Strategic Vehicle Safety and Environment Group, Accessible Public Transport Committee, Data Action Network, Transport Security Committee.

Figure 6. Transport and Infrastructure Council governance model (Transport and Infrastructure Council, 2014).

Once the Transport and Infrastructure Council has endorsed a national policy framework for IPD and BIM, Standards Australia can serve as forum to develop national standards and general conditions of contracts that can support the role out of these models. This effort can be supported by the work already done by other organisations such as NATSPEC, buildingSMART, Austroads and SBEnrc.

As seen internationally, having a mandate can help the industry move forward in a coordinated and consistent way. Defining a date for implementation and roll out provides the industry and supporting bodies a timeline within which to work by targeting outputs and allocating resources accordingly.

For example, numerous reports have raised skilling the construction workforce in the use of new digital technologies such as BIM as one of the key challenges to be faced by Australia in the near future (buildingSMART Australasia, 2012; AMCA, 2012; Australian Institute of Architects, 2010). Widespread adoption of digital technologies such as BIM/VDC will require the development of technical (most users need basic BIM skills), human and conceptual skills across project teams (Li, et al., 2008; McGraw Hill Construction, 2008). A mandate would provide the necessary context for knowledge providers (such as TAFE institutes and Universities) as well as professional organisations (such as EA and CCF) to collaborate to produce new courses to upskill the labour force in preparation for the roll out date.

APCC and ACIF have started a project titled *Education and Skills Program for PTI and BIM*. This project aims to *develop a draft strategy for an education and skills program for industry and clients* (NATSPEC, 2014). This kind of initiative should be supported by the whole construction industry and can serve as a forum for knowledge providers to produce a national skills program that allows the uptake of IPD and BIM.

16.Proposed Milestones for IPD & BIM Adoption in Australia

This section summarises the recommendations proposed in the discussion and provides a potential timeline.

2014	**Australian Productivity Commission** recommended considering BIM for complex infrastructure	Leadership
	APCC-ACIF Education and skills program for PTI and BIM	
	TISOC agrees to National Pilot and Lessons Learned Program	
2015	**Austroads - SBEnrc** develop guidelines for program including standards and metrics in consultation with industry with support from APCC, ACIF, NATSPEC, State Agencies	Metrics
	Working Groups formed to develop program and lessons learned; State agencies choose strategic projects and coordinate lessons learned across Australia	Pilots
2016	Evidence-based recommendations are made to **TISOC** by **Working Group**	Client Role
	Education and Skill providers finalise BIM coordinated curriculum	Skills
2017	**TISOC** advices Transport and Infrastructure Council based on results	Client Role
	Transport and Infrastructure Council issues mandate and start date	Mandate
2018	**EEA, CCF, TAFE and Universities** already providing relevant courses with input from other industry associations such as ACA, MBA, FMA, among other	Skills
	Standards Australia publishes BIM – IPT standards with support from APCC, ACIF, NATSPEC, State Agencies and Industry stakeholders	Standards
2019	**BIM is rolled out** industry wide based on proven benefits and a prepared industry	BIM Uptake

Figure 7. Proposed milestones for Australian IPD and BIM uptake.

17.Conclusions

This report summarises the research findings from a series of interviews and desktop research on the development of a national strategy for IPD and BIM in Australia and Sweden. There were six themes identified by interviewees from a cross-section of the transport infrastructure industry as relevant to the development of a national strategy for BIM uptake and IPD implementation. These are:

(i) Lead agent role
(ii) Client role
(iii) Mandates
(iv) Pilot projects
(v) Metrics
(vi) Standards

Additionally, the research team developed and applied a conceptual framework for mapping the peak bodies that can influence the uptake of new technologies in the transport infrastructure industry of Australia and Sweden. The framework is based on the role, processes, sphere of influence and impact of the relevant organisations identified by industry experts. The peak bodies were classified as goal-seeking systems, polities and economies as described by Young (2001).

The three main differences found between the two countries were:

(i) **The level of complexity:** the Australian map showed a high level of complexity with a diversity of types of interactions between the different industry peak bodies.
(ii) **The type of goal-seeking systems:** Australia does not have a pure goal-seeking system; suggesting a lack of harmony between key players and a fragmented industry.
(iii) **The level of input and type of interaction between the different peak bodies:** Australia seems to have a more unidirectional approach than Sweden. Here the peak body identified as a goal-seeking system only receives input from the other peak bodies but does not provide an active contribution to the development of outputs and strategy. This limits the relevance and impact of those efforts. In Sweden, Trafikverket has established bi-directional liaisons with polities and economies that jointly act as supporting and leading agents.

These differences have led to the Trafikverket being able to lead the way to a wider implementation of BIM with the support of the industry and academia for the development of standards and tools. It was also found that the three-tiered level of government, the competitive market economy and the style of governance chosen by Australia appear to act as limiting factors for a widespread uptake of BIM spearheaded by a clear leading agent.

However, the Transport and Infrastructure Council could take this leadership role and drive the industry transformation effort supported by the forum and expertise provided by TISOC and Austroads. Based on the Swedish experience it would seem that this process can be most efficient if a bi-directional line of communication is established between TISOC and Austroads. Thus, actively engaging all transport authorities in the development of outputs that would be submitted to TIC for discussion and approval.

The research team used the findings from this research to develop a series of recommendations and milestones for the development and implementation of a nationally consistent strategy for the uptake of IPD and BIM.

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19. Appendix 1 – Acronyms

AAA	Australian Automobile Association
AAC	Australian Aluminium Council Ltd
AAMCoG	Australian Asset Management Collaborative Group
AANZFTA	ASEAN-Australia- New Zealand Free Trade Area
AAS	Australian Acoustical Society
AASHTO	American Association of State Highway and Transportation Officials
ABCB	Australian Building Codes Board
ABSDO	Accreditation Board for Standards Development Organisations
ACA	Australian Constructors Association
ACCAN	Australian Communication Consumer Action Network
ACCI	Australian Chamber of Commerce & Industry
ACELG	Australian Centre of Excellence for Local Government
ACHS	Australian Council on Healthcare Standards
ACIF	Australia Construction Industry Forum
ACS	Australian Computer Society Inc.
ACT CWD	Australian Capital Territory Commerce and Works Directorate
ACTU	Australian Council of Trade Unions
ADA	Australian Dental Association Inc.
AFE	Australasian Fire and Emergency
AIA	Australian Institute Of Architects
AIB	Australian Institute of Building
AIG	Australian Industry Group
AIIA	Australian Information Industry Association
AIMM	Australian Institute of Mining & Metallurgy
AIP	Australian Institute of Petroleum
AIRAH	Australian Institute of Refrigeration, Air-conditioning and Heating
ALGA	Australian Local Government Association
AMA	Australian Medical Association
ANMF	Australian Nursing and Midwifery Federation
AOQ	Australian Organisation for Quality Inc.
APCC	Australiasian Procurement and Construction Council

APEC	Asia-Pacific Economic Cooperation
APMF	Australian Paint Manufacturers Federation
APWA	American Public Works Association
AQS	Anrika Quality Services AB
ARA	Australian Retailers Association
ARRB	Australian Road Research Board
ASBEC	Australian Sustainable Built Environment Council
ASEAN-CER	Closer Economic Relations of Australia and New Zealand
ASI	Australian Steel Institute
ATIC	Australian Technical Infrastructure Committee
AUD	Australian Dollar
BIM	Building Information Modelling
BITRE	Bureau of Infrastructure, Transport and Regional Economics
BSMA	Bureau of Steel Manufacturers of Australia
CAG	Council of Australian Governments
CCAA	Cement Concrete & Aggregates Australia
CCF	Civil Contractors Federation
CEN	Comité Européen de Normalisation (European Committee for Standardisation)
CESA	Consumer Electronics Suppliers Association
CIA	Concrete Institute of Australia
CISA	Construction Information Systems Australia Pty Ltd
COAG	Council of Australian Governments
CoE	Centres of Excellence
CPAA	Concrete Pipe Association of Australasia
CPQWG	Construction Product Quality Working Group
CRC	Cooperative Research Centre
CSBA	Council of Small Business of Australia Ltd
CSTB	Centre Scientifique et Technique du Bâtiment (Scientific and Technical Centre for Building)
CTFIA	Council of Textile & Fashion Industries of Australia Limited
CUT	Curtin University of Technology
CUTS	Consumer Unity & Trust Society

DFAT	Department of Foreign Affairs and Trade
DIER	Department of Infrastructure, Energy and Resources of Tasmania
DIRD	Commonwealth Department of Infrastructure and Regional Development
DMO	Australian Government Defence Materiel Organisation
DPTI	Department of Planning Transport and Infrastructure or South Australia
DRET	Department of Resources, Energy and Tourism
DTF	Department of Treasury and Finance
EAC	East African Community
ECMT	European Council of Ministers of Transport
ENA	Energy Networks Association
FCAI	Federal Chamber of Automotive Industries
FIF	Föreningen för Förvaltningsinformation (Association for Management Information)
FM	Facility Management
FMA	Facility Management Association
FPAA	Fire Protection Association Australia
FWPA	Forest and Wood Products Australia Limited
GAA	Galvanizers Association of Australia
GEA	Gas Energy Australia
HIA	Housing Industry Association
ICA	Insurance Council of Australia
IEA	International Engineering Alliance
IEAust	Institution of Engineers Australia
IEC	International Electrotechnical Commission
IFME	International Federation of Municipal Engineering
IPCG	APCC International Procurement Consultative Group
IPD	Integrated Project Delivery
IPENZ	Institution of Professional Engineers New Zealand
IPT	Integrated Project Team
IPWEA	Institute of Public Works Engineering Australasia
IRF	International Roads Federation
ISCA	Infrastructure Sustainability Council of Australia
ISO	International Organization for Standardization

JTC	Joint Technical Committee
JTC	Joint Technical Committee
JTRC	Joint Transport Research Centre
LCA	Lighting Council of Australia
LFV	Luftfartsverket (Civil Aviation Administration)
LOD	Level of Development
LPKF	Leveraging Procurement Knowledge Forum
MBA	Master Builders Australia
MCA	Minerals Council of Australia
MoU	Memorandum of Understanding
MPA	Master Plumbers Australia
MRWA	Main Roads Western Australia
MTAA	Medical Technology Association of Australia
NATA	National Association of Testing Authorities Australia
NECA	National Electrical and Communications Association
NIS	National Interest Services
NSCA	National Safety Council of Australia Ltd
NSW DFS	NSW Department of Finance and Services
NSW RMS	New South Wales Roads and Maritime Services
NT Transport	Department of Transport Northern Territory
NZ MBIE	New Zealand Ministry of Business, Innovation and Employment
NZTA	New Zealand Transport Agency
OECD	Organisation for Economic Cooperation and Development
PASC	Pacific Area Standards Congress
PCA	Packaging Council of Australia
PCA	Property Council of Australia
PCIA	Plastics and Chemicals Industries Association
PIPAA	Plastics Industry Pipe Association of Australia Limited
PNG CSTB	Papua New Guinea Central Supply and Tenders Board
PTI	Project Team Integration
QDHPW	Queensland Department of Housing and Public Works

QTMR	Queensland Transport and Main Roads
RA	Roads Australia
RACI	Royal Australian Chemical Institute Inc.
REAAA	Road Engineering Association of Asia and Australasia
RFI	Request for Information
ROI	Return on Investment
SCOTI	Standing Council on Transport and Infrastructure (Transport and Infrastructure Council since May 2014)
SEK	Swedish Krona
SEM	Sustainable Expertise Model
SIAI	Swedish International Alliance for Interoperability
SIS	Swedish Standards Institute
SAWTEE	South Asia Watch on Trade, Economics and Environment
TAC	Transportation Association of Canada
TACA	The Australasian Corrosion Association
TAMS ACT	Territory and Municipal Services Directorate Australian Capital Territory
T&I Council	Transport and Infrastructure Council (Previously SCOTI)
TISOC	Transport and Infrastructure Senior Officials' Committee
TEN-T	European Trans European Network
V-CON	Consortium Virtual Construction for Roads
Victoria DTF	Victoria Department of Treasury and Finance
VDC	Virtual Design and Construction
VTI	Statens väg- och Transportforskningsinstitut (National Road and Transport Research Institute)
WAPARC	Western Australian Pavement Asset Research Centre
WSAA	Water Services Association of Australia Inc
WTIA	Welding Technology Institute of Australia

20.Appendix 2 - Interviewee quotes

Some quotes have been paraphrased to improve clarity.

20.1. Industry Strategy and Activity- Australia

Comments from Australian interviewees specifically addressing strategy were limited, with two contractors (including one SME), one client and one skills provider providing comments addressing this issue.

- *Industry business focus:*
    - *Doing presentations within our organisation to promote that BIM is being one of the key enablers for business… For developing our strategy, I'm really the conduit and I'm participating in some like buildingSMART groupings on procurement.*
    - *There is no formal business strategy directing this move, but we are busy developing a strategy. I'm not aware of any company that has it* [an IPD/BIM business strategy].
    - *We don't have that capacity in house* [to use BIM]… *that's a deliberated strategy… we engage specialist consultants to do our design work when necessary, including for 3D virtual modelling. Our strategy is to not have high overheads, but buy in specialist resources when and if we need them.*
- *Government industry-wide focus:*
    - *So Standards Australia would then have some sort of a BIM protocol. I think in their next review they're seriously considering putting in some clauses and protocols around BIM … on inter-agency special committees. It would have to be very cross functional, bring in engineers, technology guys, and somebody like a buildingSMART.*
    - [Local client] *have a pretty strict drafting standard in the way we produce drawings and how things are documented. It would be fantastic if they built on that and started creating a BIM standard or a BIM strategy for the bridge projects.*
- *We invested in that model as risk mitigation strategy. We had a lot of stakeholders that we needed to engage and make sure they were aware of what we're doing to avoid problems later on. It gave us the opportunity to explain various parts of the job [and] how we were going to build it*.
- *We have an incremental learning strategy.*
- *We are looking to target smaller organisations for our Engineering Online courses. We have a special strategy for the small organisations for accessing CPD through Engineering online.*

20.2. Industry Strategy and Activity - Sweden

Eight of the 10 interviewees discussed issues of strategy; of these, four were contractors, two were design consultants, one a public client and one an expert. Points highlighted include:

- [Trafikverket] *plans to use BIM on bigger projects, as pilots, because they have the power and we can work with it with industry. Then we go into smaller projects afterwards. Now we have four big pilot projects.*
- *'It's a part of a nationwide efficiency program, where we think we are going to save about 205 million krona per year using this, with less waste'*
- *Broad focus required:*
    - *Our strategy is to continue to increase the level of implementation or levels with all actors. We work a lot with IPD, trying to not just focus on one technology.*
    - *Trafikverket is also a large funder of research, they have their own program. The only problem is perhaps that they focus on tools and practical guidelines, because that's easier.*

- *I think what's important for BIM to be really is that you need to have an organisation and process, not only the technical tools.*
- *To have capabilities across all the vendor products, that's our strategy, we don't have anything on one leg. We are able to go in a different direction and use the best products suited to that project.*

- *Research as part of strategy:*
  - *In Sweden we have clear goals on what to reach and what kind of projects we are doing with BIM. And yes we have a strategy including national research programs or smaller programs funded by construction industry finances. What is called a national strategy (or a roadmap) comes from the financiers (Vinnova).*
  - *Only a select number of companies are interested in research, and that is primarily the larger companies and the number of smaller SMEs who really have a strategic plan in order to develop themselves further into the market.*
- *Industry focus:*
  - *Strategy development is being led by clients and their expectations. As consultants we have a proactive approach to the use of being in our business*
  - *We (Contractor) took a fairly early decision in 2007 to implement VDC and this approach has been implemented widely which means getting a lot of input from the organisation (regarding) their demands, wishes, processes, methods, and technical aids that they would like to have.*
  - *There are some consultants who want to be ahead of the game in order to set up training and set up different types of competencies and all that concerning BIM but this is a limited number of consultancy firms.*
  - *'We see* [migrating to BIM] *as a way of surviving also to help out and mining future competence flow back to us… Making sure that the competence is still there in ten years, fifteen years, seven years, five years'*

20.3. Lead Agent Role - Australia

Eight of the 11 interviewees made relevant comments regarding various players in Australia who contribute to a leadership role in this field.

- *There is no agency coordinating this effort nationally, but there are a number of organisations working in this space*[4]*:*
  - *Standards Association –BIM protocol/clauses on their next review.*
  - *Any inter-agency committee would need to be very cross functional like Austroads or ARRB with broad representation.*
  - *Professional associations (e.g. Engineers Australia) have a role to: represent individuals; encourage people towards best practice; create awareness, legal and insurance frameworks; but do not the initiative or desire to make these changes.*
  - *Other industry bodies represent a particular discipline.*
  - *Large design and construct firms can do 'show and tells' but are not industry leaders.*
  - *BuildingSMART is probably the closest we have to a figurehead organisation.*
  - *Consult Australia involved in procurement activity.*

[4] Italics are used throughout this document to denote views expressed by interviewees. Where they are direct quotations, quote marks are used.

- *Alliancing Association Australasia – worked for about 13 years in this space and now handed over to Centre for Collaborative Contracting*
- *BrisBIM - http://brisbim.com/*

- *A national umbrella organisation is required to ensure consistency and to tie to cadastral information to the overall framework – e.g. Virtual Australia and New Zealand - http://www.vanzi.com.au/ and the Construction Industry Council in the UK - http://www.cic.org.uk/ .*
- *Need a level of acknowledgment across government bodies, that is, 'over the next three years we're going to pilot 5 BIM projects'*
- *Road construction industry is mostly government funded. If government specifies what it wants that would drive the whole industry.*
- *We've got design manuals and documents, and minimum standards (e.g. AS Standards, TMR standards) but these are not connected in any sense (e.g. bridge work, to lighting to what's in the ground).*

20.4. Lead- agent role - Sweden

- *International competition leading to national collaboration:*
  - *Very open collaboration within Sweden because they don't seek in as such as being competitive, see it as a national approach because of competition from German French and Polish companies. Norway is very much at the forefront right now.*
  - *In Sweden we have a much broader implementation but not as deep as in Norway and Finland where government clients are very clear about the VDC requirements.*
  - *Look to the Finnish guys because they have big research programs targeting BIM*
  - *OpenBIM is an organisation in Sweden of over 100 companies working together*
- *Lead role of contractors and consultants:*
  - *Skanska have a network of people working on BIM promoting them with the designers probably leading the chain.*
  - *When working with consultants we (the contractors) to have our own standards.*
  - *I think contractors have been in the lead because they have implementation projects funded by SBUF. And then there is FORMAS and Vinnova (running and innovation program to the construction industry).*
  - *while the public organisations haven't pushed BIM development you see larger consultancy firms and contractor firms taking a large part of the leadership*
- *Trafikverket*
  - *Can specify vendor specific probe products but tend not to specify products but rather CAD formats, which can indirectly point towards different venders.*
  - *The goal is to lead development of virtual construction together with the market*
  - *develop standards, look to the efficient and effective data exchange between information modelling, and maintain up-to-date asset and facility management data through the use of the ProjectWise*
  - *as the largest client it is a kind of agent of innovation which can drive the sector forward through their contracts by saying "you need to use them, you need to do this, because we are the largest act on the market, and we have the power to do this, and we can actually make a change that way"*

20.5. Client Role- Australia

Eight of the 11 interviewees made relevant comments regarding the nature of client drivers or the need for clients to drive implementation of both BIM and IPD. Comments are included from two contractors (SMEs), three clients, one educators/expert and one designer. Comments included:

- *Client as lead agent:*
    - *The purchaser, that is the client, is the key driver for these things and procurement is the key driver of change.*
    - *Clients need to understand what they want and set certain boundaries before they bring contractors on board.*
    - *Driven by our key clients who dictate certain types of software and drive the program and costing schedule. If the client plays by the rules and industry works and what they have to do to put their best ideas forward and can price it on a level playing field then it's a really good way to encourage industry to bring ideas to table.*
    - *If we want to realise efficiencies to the whole project life and it's really a client responsibility and setting standards and management information which is going to be used consistently across the whole of life of the project.*
    - *Clients need to first know and understand what they are after, what the end game is, what information will be used for, and provide clear guidelines to contractors. They also need to know what they need for the different stages of the project that is 4D model of construction stage might not be so relevant to the asset management stage.*
- *Clients leveraging outcomes*
    - *Once we get the deliverable we should be on to write extractors and tools to extract the bits and pieces out of it and go into various other management and asset systems.*
    - *Once we created or tools & design checkers these are all available for free download and access by consultants and contractors.*
    - *RMS has a pretty strict drafting standard with a library of standard elements and shapes of bridge elements. If designers could get access to these this would speed up the process.*

20.6. Client role - Sweden

All by one of interviewees discussed pilot projects comprising four contractors, one client, two consultants and two experts. Comments included:

- *Defining functionality:*
    - *We must define the process, at least the functionality, that is what we want to do with the model and what kind of functionality to model should have. We have to have a picture ourselves of the whole process, as builds management maintenance and whether the asset managers have input into the process.*
    - *Hoping that Trafikverket will take responsibility for the model quality. They give us fairly detailed and good quality models are used in a bidding process.*
    - *Clients who know what they want and can explain it, then leave them (the contractor) alone to produce the product for a good quality good money and on time.*

- *We have long-term owners and clients involved in providing a much better scope of what is required, not just in design and construction but on the whole of life.*
- *Government clients need to be specific in what they want for themselves. We see quite a number of projects with clients make some kind specific general and/or specific BIM requirements without actually having a reason for it.*
- *There is a clear wish especially from consultants and contractors to gain different types of contracts from the clients, what do we really need to deliver and what we need to do.*

- *Government/client as lead agent:*
  - *Governments must take the lead. The benefits of working the BIM way and it comes from close collaboration. If one member of the team is using them while others continue doing things the old way, there will be limited benefits. To make the investment worthwhile someone has to break the stalemate, and that someone is often the government.*
  - *In the last few years the government clients, primarily Trafikverket are pushing ahead very fast with VDC or BIM development.*
  - *Trafikverket have a major role in really pushing the whole business and market ahead, and they are demanding BIM and VDC on all new jobs.*
  - *Unless the leading client specifies the expectations of BIM/VDC it simply won't happen.*
  - *A number of clients are now coming together and trying to take part of the leadership role in the development has been*
  - *Trafikverket are not doing it to promote projects where they used BIM but because they will see benefits to make it cheaper to produce, to have better quality and better asset maintenance.*
- *Industry as driver:*
  - *It is the contractor who is the main force in Sweden and actually require the consultants to deliver everything in 3D. It's not like in Finland Norway where the clients are pushing or pulling the development. Clients have been very passive until just recently.*

20.7. Mandates - Australia

Six of the eleven Australian interviewees spoke of mandates - three contractors (two SMEs); one a consultant; one a client; and one expert/educator.

Interviewee comments[5] include:

- *No demand for mandate*
  - *The government is not particularly pushing any BIM initiatives. There are no particular regulations and rules that the government puts on companies like, for example, in the UK where they are requiring BIM to be part of the projects.*
  - *Client base is not mandating integrated project delivery.*
  - *Don't need a full-blown mandate – test the water and if it works go with it.*
  - *Don't think a mandate from government is necessary, but a consensus on technical guidelines and standards is required.*

[5] Interview comments in italics throughout document

  - *The last thing we want to see something new - rather identify some pilot projects and if that goes well then share information across industry.*
  - *'there's got to be some, I don't like using the word mandate, but there's got to be some level of impetus for it… it can be as I said just half a dozen projects over the next three years spread across four agencies'.*
- *Driver for a mandate*
  - *It could be a high level mandate with the State authorities forced follow. This would provide software developers with consistent objectives to deliver to, to develop plug-ins for the Australian market, and bring costs down.*
  - *It would just take a single state authority or sector (e.g. health) to mandate the use of BIM and skills upgrade and benefits would follow.*
  - *Federal government 2016 BIM mandate is more like you've got to start looking at it and have it ready.*
- *Experience with mandates*
  - *BIM was mandated as a deliverable for a hospital project (FM deliverable for BIM LOD 500) but without clear understanding.*

20.8. Mandates - Sweden

Four of the 10 interviewees discuss mandates. This included two clients, one contractor and one expert.

- *We have made a decision for all construction projects to use them to some extent by 2015. Trafikverket is supposed to be in the front line regarding BIM but it's hard to put that down on paper, what does that mean? We are continually upgrading our expectations of contractors and designers*
- *Of the thousands of projects there are few where we are told you have to do this.*
- *BIM is required for everything over SEK50. It is enforced like push thing but you need to think of it more as a pull thing also so to see the benefits of it.*

20.9. Pilots - Australia

Five of the eleven interviewees discussed pilot projects including two contractors (two SMEs), two clients and one designer. Three current pilot projects were discussed including a road lighting package, a bridge, and 220 km of roadway. Comments included:

- *A feature project to validate that the BIM process provides the necessary gains in efficiency and productivity is required - or show how easily transferable knowledge is from the building sector infrastructure sector.*
- *We are doing a pilot project in road lighting design and we want cradle to grave models including links to our asset management systems. Road lighting was selected as it is one of the cheapest items in road geometry, because it is a very static, and it's easy to move around afterwards. Eliminate coordination issues initially, get the scheme are right, get the cycle going, and get some learnings out of it. And then move onto the next component, developing BIM standards as part of this.*
- *Finding a test bridge project as a trial and then trying to improve upon it on the next project and find out and learn more as we go*.
- *The project we are trialling it is 220 km stretch of existing road with some of the work already done through a program alliance that developed 14 design packages.*
- *Once the pilot is done we can say that works to fine tune in various regions, as information we collect here may not be relevant for a safe city.*

- *'The clients need to know that they're still getting value for money and… that they're not restricting competitiveness… that's a learning process and… a project to validate that the BIM process provides the necessary gains and efficiencies and productivities that they're looking for. I have no doubt that in the fullness of time that can be proved. It's the initial impetus… that needs to be put in place and identifying a feature project to start that going'.*
- *'If the clients are keen for industry to grab it and run with it then they need… to identify some pilot projects where they work with the delivery team to implement this on a real job or a pilot job… if that goes well then they can have an information sharing forum or session with industry to say "look, we've piloted this and we're keen to extend the pilot program to a wider group of projects and gradually apply it to more and more of their jobs'.*
- *'Get the schema first, get the cycle going and get some learnings out of it and then we can say "okay we've proved this. It works and these are the things we need to do to get it to work".*

20.10. Pilots - Sweden

Four the 10 interviewees discussed pilot projects including one contractor, one consultant, one expert and one client.

Comments included:

- *These four major demonstrator projects will help bring the focus for the industry to the financial side and also to set the standards development.*
    - *The Stockholm bypass project will set the standard for how we should deliver these kind of building information models*
- *We (Contrator) have a smaller bridge test project which is paper free even on the construction side. It is all Ipads and we get paid a different look points of the 12 bullets of BIM. We use this as a case study that we have documented and Trafikverket makes it public.*
- *We had three days of the Crossrail project in London to see the possibilities for us to use the same Bentley tools and the same BIM techniques, became convinced, and made the decision to go ahead this way on November 2011.*

20.11. Metrics - Australia

- *Statistics, figures, numbers and actual recounts from projects are required including 'this is what we did on the job this is what went really well this is what we get on too well and this is what we are doing about the bits that didn't go well'.*

20.12. Metrics - Sweden

Three of the 10 interviewees spoke of metrics. This included two clients and one contractor:

- *Difficult to determine:*
    - *We've been working on a couple of years but it's not a goal that you can really measure.*
    - *We are trying to get better at getting proper metrics for projects. In Sweden it's actually very hard to find proper metrics of the value of BIM.*
- *Productivity and process improvement:*
    - *I think we can say we are already in the process of defining where we are aiming. Trafikverket identified them as one method of dealing with the productivity committee's report and its demand.*
    - *Now its process improvement, but also looking at other countries what kind of metrics they publicise.*

- *'We need to know how to figure it* [measure success with BIM] *out how to do it also so we can see the return on investment for the client or for ourselves and so on in hard facts'.*
- *What could have been done better? Definitely better metrics to base decisions on but also more education, more open transparency of what BIM is all about, and clear descriptions.*
- *I think we save time about 75% and that means perhaps two or maybe 3 million Swedish krone every year (based on 40 billion kroner a year). Then the quality of information is also very much increased.*

- *'We're going to fewer errors from the contractor, because of the better drawings, better information, better models instead of drawings, and if you have fewer errors, we think we'll get fewer demands for extra payment, and we can measure that. And we can also look at time for design, and we can also see if there's a possibility for a contractor to plan his work better instead of drawing to have a model, it's a very long project and you can plan, optimise transportation or whatever. And we think we can show that the asset management information is much better in the end'*
- *'we'll see increases in productivity that need to be measured across several projects, say over a 5 year period, it's very hard to determine what the measures might be on a single project evaluation'.*

20.13. Standards – Australia

- *One of the frustrations for people like myself who work in south east Queensland and work over the border is the difference in standards between RMS and TMR. That's a constant frustration particularly when you're in projects like ECIs where you're being asked by your client to innovate and provide best value for money and you can see that the client organisation a hundred kilometres down the road does one thing one way and quite successfully and efficiently but because of standards and rules that apply across the border where you are that process or product isn't allowed… there's enormous benefits from having a much more consistent set of standards across Australia.*
- *There are enormous benefits from having a much more consistent set of standards across Australia… For a country as small in population as ours for there to be not more national sort of standards for all sorts of things... Australian Standards try… I would certainly strongly support the adoption of a national standard or Australian standard for this sort of stuff… the regional standards still refer to Australian Standards so… AS would be the obvious choice.*
- *We've got an office in Perth and we share a lot of projects... sometimes we work on bridges over there and vice versa and it's very frustrating to flop in between the two standards. So if there was one national standard that would be amazing… you'd eliminate a lot of duplication because obviously over in WA they've got their own standard way of detailing things. So they've got a set of a library set up to deal with that and over here we've got a library set up to deal with the client... And when you go to draw something you never think okay this is this State's way and not this other state's way so definite benefit of an overall governing body or someone that brought those more into line.*
- *Everyone does their design you know to follow the Australian standards so… they could have a BIM standard or a BIM guideline that the people follow.*
- *Standards Australia would work to develop some standards … You've got to learn from the US experience; it's exactly what they have done…* [it need to be done by] *a very cross functional committee bring in engineers, technology guys, and somebody like a buildingSMART*

20.14. Standards - Sweden

Eight of the 10 interviewees spoke of standard. This included two clients, two consultants, two contractors, and two industry experts.

There is an absolute need for standardisation

I think the technical platforms maybe not so as important as how you actually work with it.

- *Trafikverket has a third of the market in the construction area of infrastructure here in Sweden, so if they set the standard the rest will follow.*
- *Current activity:*
    - *Participating in the OpenBIM initiative, now known as the BIM Alliance Sweden* (BIM Alliance, 2014a).
    - *As a contractor we have active input into the development of Swedish standards (Swedish standards Institute) and all European standards.*
    - *This is a very big tunnelling project and what we have worked with also is a common coding standards that layers and all information in the objects you have in the 3-D models. This is more or less the standard in Sweden anyway. We try to have a way of working so the designer can use any software they want, but it's not really possible if you work with ProjectWise. We have a standard code system with Layers*
    - *This is part of bringing road and rail together in Trafikverket, to bring some standardisation. What we have is ProjectWise; and we have a GIS integration, designers, different technical areas, different locations they can work in Poland, England. We have people working all over Europe and in India for example. And we used to factor standards such as BSAB, BIM standard construction information.*
    - *There is a standard set of objects which are available to all designers in the industry through ProjectWise. We give them the platform ProjectWise, as a BIM server, you can use any software you want. But when you're going over to asset management system, we specify exactly how it should look. They can deliver the as built information that we can use that is the CAD files, naming conventions, everything is specified for the final asset management system so it is easier if they use for the whole project.*
    - *There are a number of companies and government agencies working together now to set up standards and a set of particular ways of working.*
- *Lack of clarity*
    - *It is difficult in getting a clear standardisation as there are too many different stepped up standards that are used by different companies.*
    - *It is still unclear and many firms what kind of particular elements they should put into the contracts in order to get a good final end result.*

21. Appendix 3 - List of Interviewees

Actor	Role	Australia	Sweden
Client Organisation or Asset Owner	Procurement Manager	New South Wales Roads and Maritime Services (NSW RMS)	Travikverket Roads
		Queensland Transport and Main Roads (QTMR)	Travikverket Rail
		Main Roads Western Australia (MRWA)	
Designer	BIM Manager	AURECON	SWECO
		BG&E	WSP
Contractor	BIM / Project Manager	John Holland	NCC Construction
		Seymour Whyte Constructions	Skanska
		McIlwain Civil	
Supply Chain/Technical Expert	Industry Expert	buildingSmart, BIM group	Luleå University of Technology
		Engineers Australia	Chalmers University
	Professional Association Leader	Infrastructure Industry Skills Council	Swedish Construction Federation (BI)