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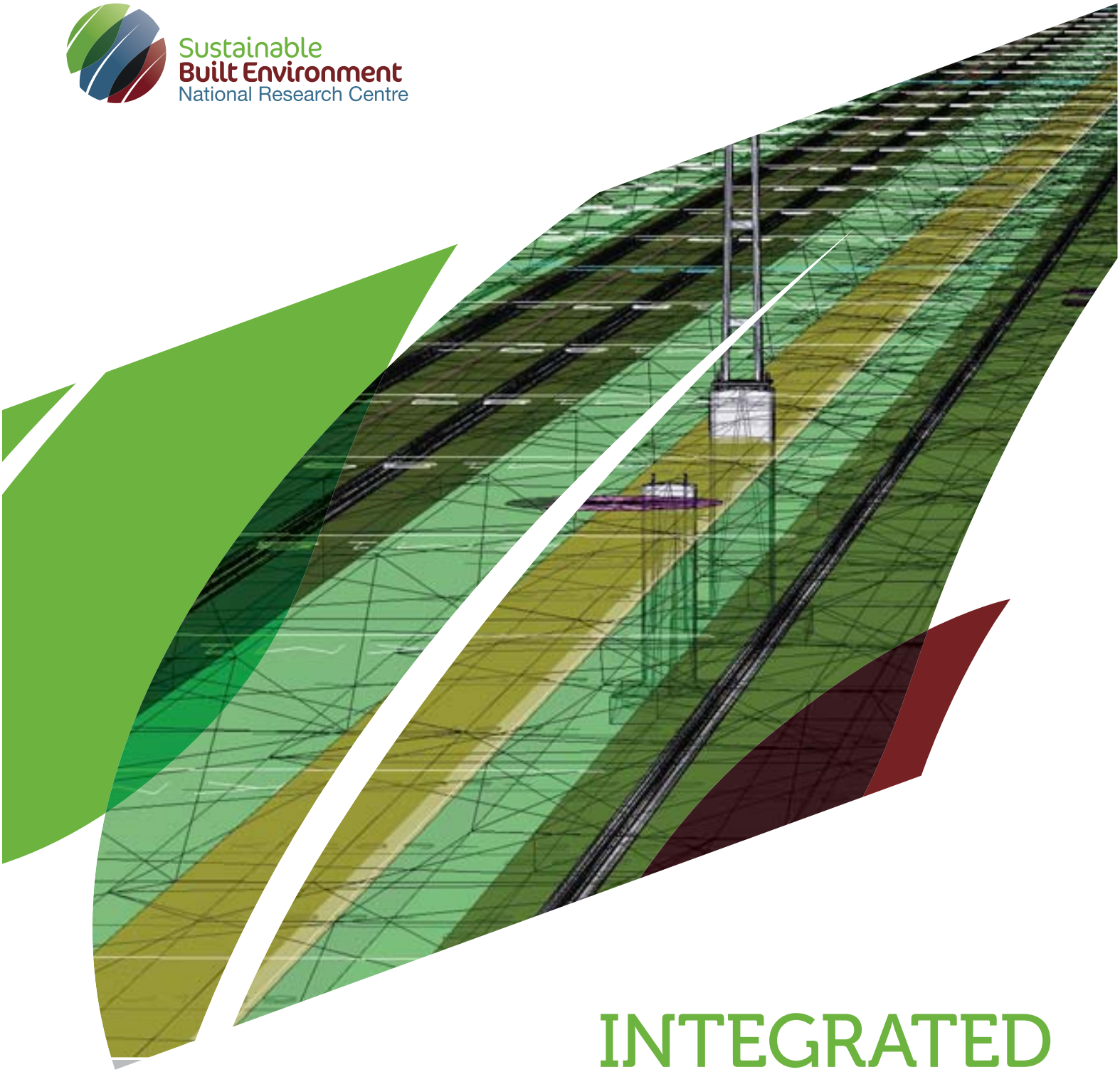

INTEGRATED PROJECT ENVIRONMENTS

Leveraging Innovation for Productivity Gain through Industry Transformation

Keith D Hampson | Judy A Kraatz | Adriana X Sanchez

Acknowledgement

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These organisations have provided support for the research undertaken by the Sustainable Built Environment National Research Centre by providing feedback and advice regarding the research outcomes and final dissemination strategy. However, endorsement should not be assumed.

The Sustainable Built Environment National Research Centre (SBEnrc) is the successor to Australia's Cooperative Research Centre for Construction Innovation (2001-2009). Established on 1 January 2010, the SBEnrc is a key research broker between industry, government and research organisations servicing the built environment.

The SBEnrc is continuing to build an enduring value-adding national research and development centre in sustainable infrastructure and building with significant support from public and private partners around Australia and internationally.

Benefits from SBEnrc activities are realised through national, industry and firm-level competitive advantages; market premiums through engagement in the collaborative research and development process; and early adoption of Centre outputs. The Centre integrates research across the environmental, social and economic sustainability areas in programs respectively titled Greening the Built Environment; People, Processes and Performance; and Driving Productivity through Innovation.

Among the SBEnrc's objectives is to collaborate across organisational, state and national boundaries to develop a strong and enduring network of built environment research stakeholders through collaborative industry research teams.

Essential to SBEnrc achieving its goals is this core project Integrated Project Environments: Leveraging Innovation for Productivity Gain through Industry Transformation.

Dr Keith D Hampson
Chief Executive Officer
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Introduction

This project has delivered:

(i) Recommendations for policy makers to achieve a nationally consistent strategy regarding the implementation of building information modelling (BIM)/Virtual Design and Construction (VDC)

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

(iii) A dissemination strategy that includes providing informative material to different levels of the supply chain through our work with organisations such as Civil Contractors Federation (CCF) and Engineers Australia (EA), as well as through our partner organisations and media resources (e.g. YouTube channel and industry publications).

This publication summarises the outcomes of the Integrated Project Environments SBEnrc project. Detailed information can be found in the supporting publications cited on the final page of this document, together with a list of acronyms.

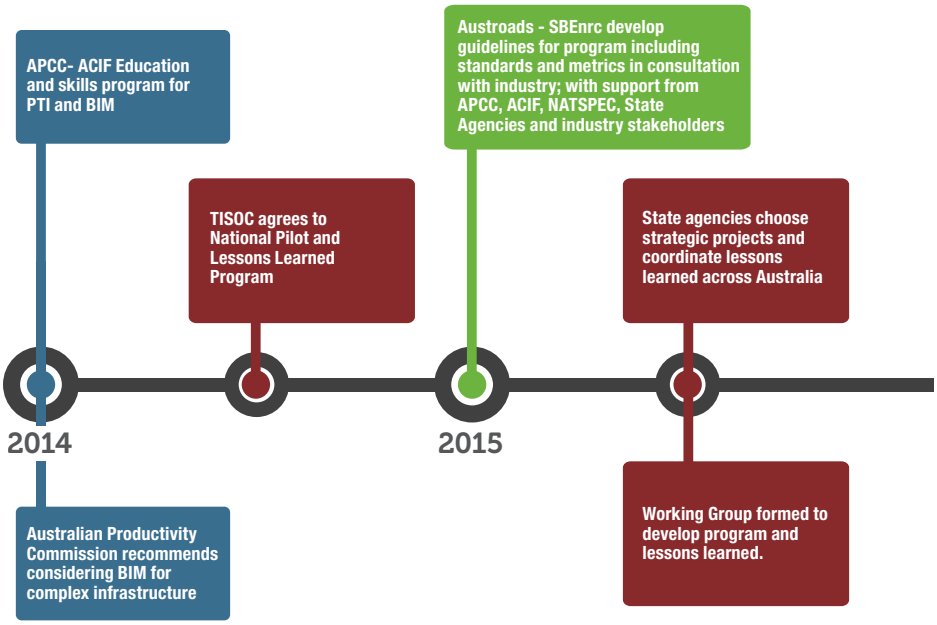
This research contributes to realising productivity benefits of digital modelling and integrated project delivery for the Australian construction industry through the use of BIM and VDC in the delivery of transport infrastructure projects. This project addresses procurement, process improvement and technology required to encourage more effective BIM and VDC uptake. Data was collected through interviews in Australia and Sweden (one of the acknowledged global leaders in this field).

BIM/VDC has been identified as an important emerging and transformative enabling technology, with the potential to streamline processes throughout the constructed facility lifecycle. The Australian Productivity Commission (2014) highlights that more widespread adoption of BIM/VDC could enhance productivity across the building and construction industry and in turn have a significant beneficial impact on the cost of delivering and managing infrastructure.

Additionally, current education systems and structures are based on traditional document-based processes (Newton, Hampson and Drogemuller, 2009), creating a skills gap that will need to be addressed as implementation of BIM/VDC becomes more widespread.

Project objectives

This research aims to: (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 skills gaps especially for SMEs, within the context of Integrated Project Delivery (IPD) in Australia.



Objective 1:

Inform a national strategy for the adoption of BIM/VDC

This project aimed 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 BIM-enabled project environments.

(iii) Development of a dissemination strategy to different levels of the supply chain through work with organisations such as CCF, EA and Austroads, as well as through 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 IPD.

(v) Explore the role of consensus-driven peak bodies 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 an increasingly global business environment. This research was based on strong collaboration between industry, government and researchers both in Australia and internationally.

This first objective of the research addressed the first and last of these five areas, and provides a discussion of six key themes identified as relevant to the development of national strategy for IPD uptake:

(i) Lead agent role

(ii) Client role

(iii) Mandates

(iv) Pilot projects

(v) Metrics

(vi) Standards.

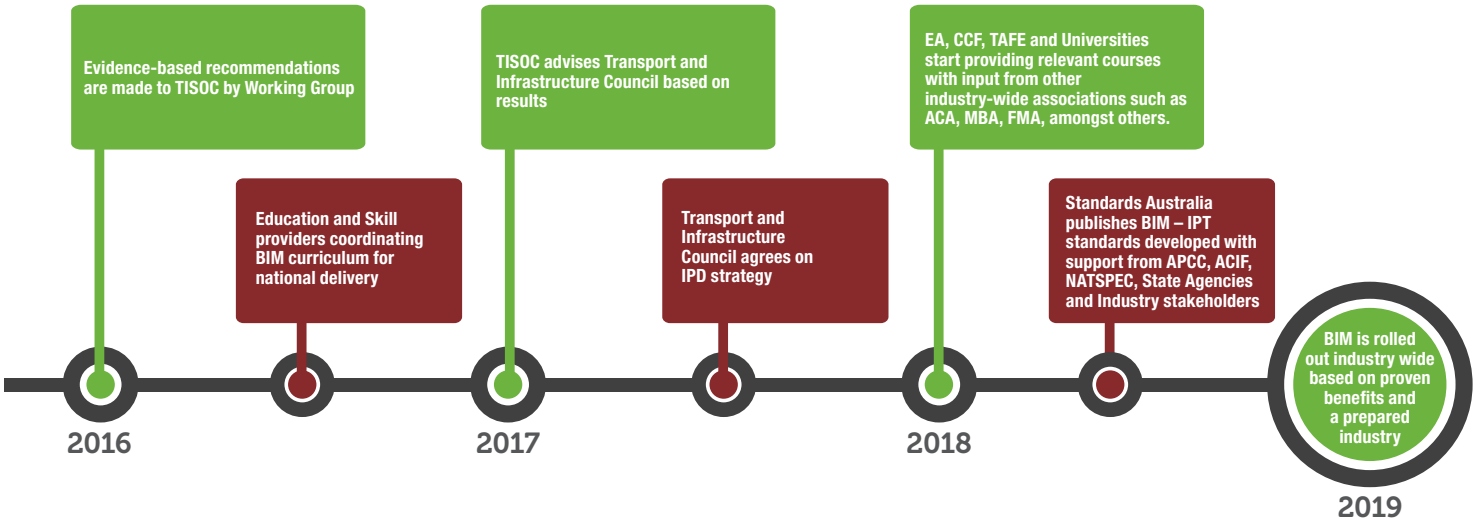


Figure 1: Proposed milestones for a national strategy for adoption of IPD and BIM in infrastructure

Issues considered relevant to a national strategy:

(i) The leadership and coordination of lead agents[1], and engagement with industry associations is important in 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 process to improve industry performance.

(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 to provide the industry with the incentive and consistency to invest in the development of a program of coordinated actions.

(v) Building consensus on standard performance indicators and metrics is valuable 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 productivity 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 series of proposed 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 (Figure 1). The Transport and Infrastructure Council[2] was identified as being in the best position to take this leadership role.

[1] Organisations or individuals who can mobilise the knowledge, resources and energies of a host of public and private actors (Sørensen & Torfing, 2009)

[2] The Transport and Infrastructure Council brings together Commonwealth, State, Territory and New Zealand Ministers with responsibility for transport and infrastructure issues, as well as the Australian Local Government Association. This body is the successor to the Standing Council of Transport and Infrastructure (SCOTI), successor to the Australian Transport Council

Objective 2:

Guidelines for new contractual frameworks

Integrated approaches involve contractual relationships that are quite different from traditional contract models **and this can therefore be a challenge for procurement managers who wish to implement IPD and BIM (AIA, 2007). To address this issue the research team carried out a document review based on the 3xPT Strategy Group IPD Principles for Owners and Teams report.[3] Documents reviewed include contract agreements, manuals and guidelines issued by: Queensland Transport and Main Roads (QTMR), New South Wales Roads and Maritime Services (NSW RMS), Main Roads Western Australia (MRWA), UK's Chartered Institute of Building (CIOB), the American Institute of Architects (AIA), AEC (UK) Committee and NATSPEC.**

The review of contract agreements focuses on Design and Construct (D&C), Early Contractor Involvement (ECI) and General Conditions of Contract documentation, which was publicly available or provided by participating organisations.

The primary finding is that most of the organisations address the majority of the issues used in the document review. However, the key differences between these organisations are: (i) the level of detail to which each topic is addressed; and (ii) whether the way in which they are addressed is compatible with the principles of IPD and potential use of BIM/VDC.

The document review was used to analyse these two issues, compare the appropriateness of each organisation's approach and, where relevant, provide recommendations as to how current practices could be modified based on the aforementioned analysis.

Key general recommendations include:

1. **Use of clearly defined Levels of Development (LOD)[4]** for each model element and project phase, recorded in a BIM Management Plan document. These should be defined not only based on the geometry and performance specifications, but also in more specific terms such as for example responsible roles and submission dates.
2. Procurement managers to consider the benefits of including **subcontractors in the project team** and their contribution to the design and construction process to be included in the BIM Execution/ Management Plan.
3. Project teams to develop a **strategy to update and coordinate changes** at the earliest stage possible. Additionally, **linking financial bonuses to savings** produced by enhancements to the design or project delivery can create a clear incentive for more innovation, collaboration and time/cost efficiency gains.

[3] Developed based on consultation of cross-functional teams composed of owners, architects, contractors, subcontractors, consultants, attorneys, and insurers to explore and define integration options within both existing and new delivery models. The report sets "first principles" of IPD applicable to all delivery models.

[4] LODs describe the level of completeness to which the model element will be developed in terms of specific minimum content requirements and associated authorised uses (AIA, 2013).

4. **Specific BIM/VDC performance metrics** to be included in the BIM Execution/Management Plan, including success parameters. For clients looking to integrate their data systems, these **metrics should be aligned with the facility/asset management system** requirements to allow integration of data throughout the supply chain.
5. The risk of non-performance should be shared among participants equally. If participants are not comfortable doing so, **risk apportioning should be agreed upon** in the contract. Alternatively, **clearly defining ownership over design elements** and hand-over processes would reduce the risk of conflict and allow the use of more traditional risk apportioning.
6. An **integrated project coordination role** is required to coordinate, facilitate and provide direction for the integrated team.
7. Prepare a **BIM Protocol Addendum and technical specifications** for the contract agreement that redefines terms, procedures and metrics and can be added to BIM-enabled projects. This should be a contractually binding document.

D&C contracts could be adapted to include IPD principles by contractually increasing client involvement, linking financial benefits to project goals and using open book accounting. However, ECI and other relationship-based contract models offer the best integrated collaboration with all relevant participants closely involved in the project development from early stages. Integrated contract models can use relationship management plans, collaboration standards and regular meetings to maximise the efficiency and quality of the works. Additionally, these offer the benefit of using more interactive and collaborative procurement models that allow the selection of the preferred construction team based not only on their technical and management skills, but also on their commitment to an integrated delivery and collaboration processes.

Finally, the documents were also reviewed in terms of potential to educate and up-skill the labour force. Although specific programs related to IPD and BIM/VDC were not found, requirements such as the ECI's Skill Development Plan and General Conditions regarding Enterprise Training Management Plans could be used as tools to reduce the skill gaps on a project-by-project basis.

Detailed recommendations are then divided into (i) modification/expansion of current practices; and (ii) new considerations as shown in Figure 2.

MODIFY

NEW

DOCUMENTATION

- **Contracts:** Add clauses that bind addendums to subsequent contracts, reflect authorship and confidentiality and require latest protocol version to be included in model
- **Scope of Works and Technical Criteria:** Add BIM Management Plan (BMP), considering subcontractor contributions
- **D&C Deed Schedule:** Link Levels of Development to model elements in BMP
- **Contract Program/Preliminary Design Report:** Include BIM metrics and success criteria
- **Relationship Management Plan:** Use from ECI

- **BIM Protocol:** Develop at earliest possible project stage as contract addendum, including changes management strategy, methodologies and technologies
- **Data Sharing Protocol (internal and external):** Develop to address confidentiality; data security; user rights and ownership; authorised uses; transmission, use, storage and archiving of data
- **Contractual Clauses:** Binding protocols to avoid compliance issues

ROLES

- **Project Verifier:** Maintain independent role while expanding responsibilities to include BIM project coordination and verification (alternative to BIM Project Coordinator)
- **Design Manager:** Expand responsibilities to include BIM coordination between technical disciplines (alternative to BIM Technical Disciplines Coordinator)

- **BIM Project Coordinator:** Independent entity helps to set-up the integrated project approach, audit the model and coordinate contributions to the model and protocol
- **BIM Technical Discipline Coordinator:** Facilitates coordination of technical disciplines for BIM development, training, standards and data requirements; and team "buy-in" for collaborative integrated environment
- **BIM Strategic Coordinator:** Coordinates across projects and hand-offs between phases, manages knowledge transfer

PROCESSES

- **Tender Selection Criteria:** Expand non-price criteria of BIM enabled projects to include experience, skills and commitment to IPD
- **Bonus Clauses:** Expand benefit sharing clauses and link to clear metrics and success criteria related to project goals
- **ECI Style Workshops:** Use in other contracts
- **Risk Apportioning and Indemnification:** Agree in contract agreement and review language carefully with legal and insurance counsel
- **Skill Development Plan/Enterprise Training Management Plan:** Use to reduce skill gaps
- **Regular Update Meetings:** Address changes to protocol and include all affected parties

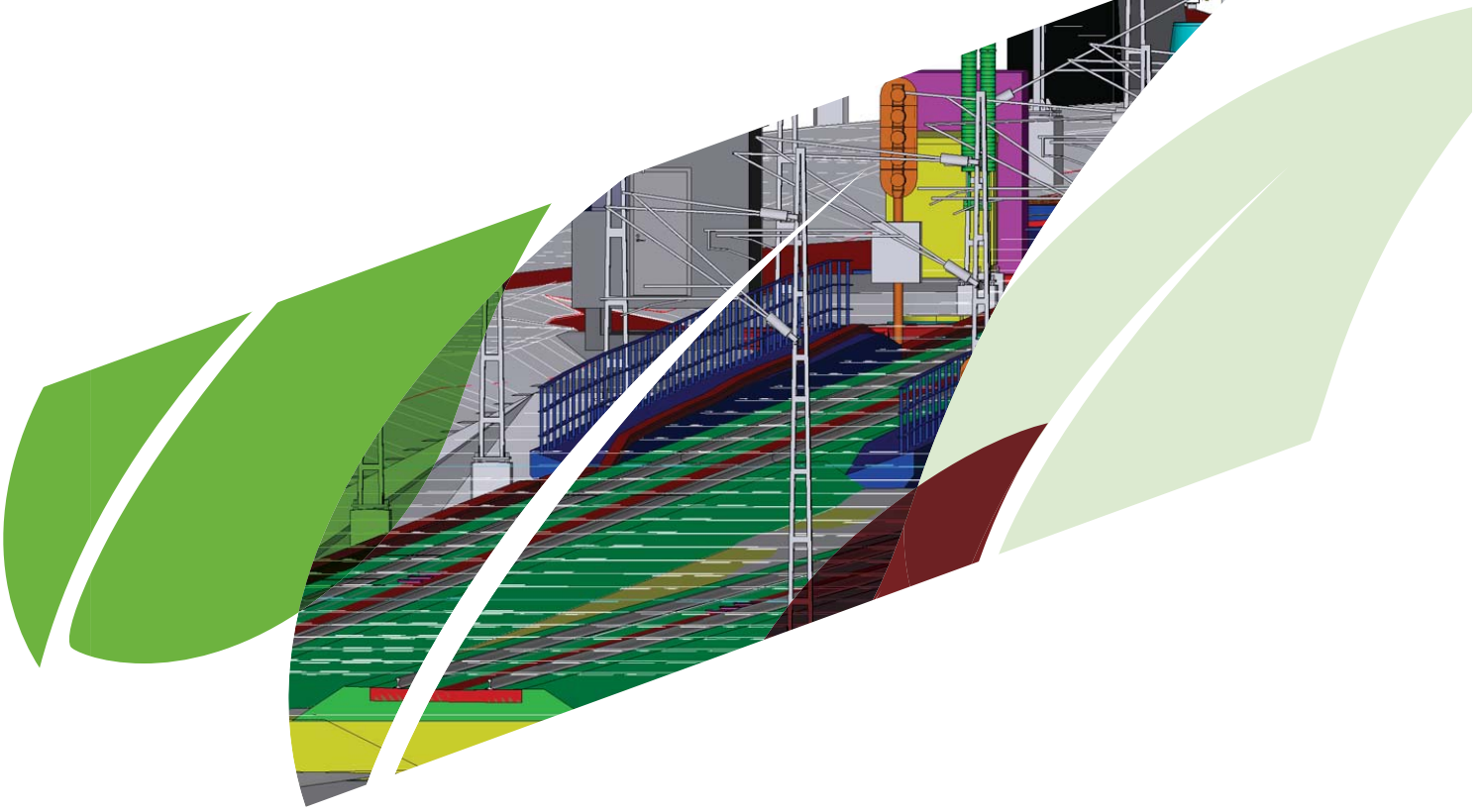
- **Element Ownership and Handing-off Procedures:** Clearly define responsibilities and procedures for evaluating, mitigating and resolving any potential issues found by other users
- **Culture:** Encourage a collaborative no-blame culture by defining as part of core values, maintaining open communications and apportioning risk adequately
- **Common Data Environments:** Establish to facilitate collaboration and data management; consider using classification system used by AEC (UK) and develop user manuals, including impact on roles of project participants

OUTPUT

- **Systems for Design Development and Data Management**: Select based on project specific considerations such as scale, cost, level of effort needed for new users, and asset management systems
- **Submissions:** Avoid physical copies, request bookmarked PDFs, native format and IFC
- **Final Submission**: Specify asset management and monitoring data only

- **BIM Outcomes (As-built) and Metrics:** Aligned with the overall system requirements of facility and asset managers as well as traditional and BIM specific metrics

Figure 2: Detailed recommendations for contractual practices for IPD and BIM



Objective 3:

Inform a strategy to reduce skills gaps especially for SMEs

Education and training costs for companies looking to adopt BIM technology will be, to a degree, eliminated when universities and other educational providers incorporate BIM training into degrees and coursework

(Allen Consulting, 2010)

To achieve the third project objective, this research provided information on three areas: (i) a current insight into relevant BIM/IPD skills more broadly; (ii) knowledge dissemination and uptake; and (iii) the role of knowledge intermediaries.

Recommendations from the analysis of a review of academic literature and industry documents, and an analysis of interview findings, have highlighted the need for a more strategic approach to skills development in this country (whether national, state or organisation-based) that addresses three tiers of decision-making and the three types of skills needed (i.e. technical, human and conceptual).

This includes:

- A need for better coordination across knowledge providers and industry support for initiatives such as the APCC-ACIF education and skills project.
- Recognising the significant benefits of stronger links between industry and academia (for example in Sweden there is a culture of embedding students in industry and involving industry professionals in education and research supervision).
- Developing support systems for capability development by SMEs such as that employed by some state agencies where contractors receive training when new processes are being adopted for project delivery.
- These recommendations then need to be integrated as a part of the milestones proposed in Objective 1: Inform a National Strategy for the Adoption of BIM/VDC. Educational and training providers need to engage with such an ongoing collaborative effort in order to continue to fine-tune and focus training and courses which are available at undergraduate, post-graduate and professional levels.

Objective 3 (Cont):

Inform a strategy to reduce skills gaps especially for SMEs

- A strategy is also proposed for disseminating research findings to upgrade skills across a three tier hierarchy of decision-makers, that is, government decision-makers, mid-level strategic decision-makers, and those involved in project and program delivery.

As part of the development of this strategy, dissemination avenues were also considered to address the skills gap at the various layers of decision-making. This project proposes a three-tiered dissemination strategy for industry research findings to build understanding of BIM, IPD and the requisite skills upgrade required within the transport infrastructure industry.

This strategy is defined by the following hierarchy:

Tier 1: Government Decision-makers;
Tier 2: Mid-level Strategic Decision-makers;
Tier 3: Project and Program Managers.

This hierarchy, showcased in Figure 3, may also be useful in terms of the design of courses to up-skill people of various levels of decision-making.

This project has directly helped reduce the knowledge gap by providing informational material to be distributed through (i) Engineers Australia's newsletters; (ii) SBEnrc's YouTube Channel[5] and newsletters; (iii) Industry focused conferences such as Institute of Public Works Engineering Australasia 2014 Conference on Sustainability in Public Works; and (iv) Producing reports to different levels of detail aimed at different tiers: Government Decision-makers, Mid-level Strategic Decision-makers, and Project and Program Managers.

[5] https://www.youtube.com/user/sbenrcvideo

Tier 1

Government Decision-makers

Target audience

Key politicians *(e.g. Federal and State industry ministers and departmental heads)*; Chief Scientists; Transport and Infrastructure Council; state road agencies, and industry peak bodies such as Austroads, Roads Australia and Infrastructure Australia

Mechanisms

- Demonstrate value of innovation to the industry and nation through informative documentation
- Face-to-face representations from research and industry leaders

Tier 2

Mid-level Strategic Decision-makers

Target audience

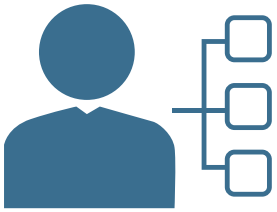
Government program directors and industry leaders

Mechanisms

Present case studies of systemic learning through informative documentation, short audio-visual materials, seminars for project partners agencies; ongoing formal exchange with industry associations e.g. NATSPEC, ACIF, APCC and buildingSMART

Tier 3

Project and Program Managers



Target audience

Industry professionals; SMEs

Mechanisms

Guideline documents; professional development programs; publications in industry newsletters and journals e.g. CRC for Construction Innovation Guide for Best Practice for Safer Construction, Engineers Australia News and magazine

Delivery

Development of short courses with materials provided by lead industry researchers and delivered in conjunction with organisations such as Civil Contractors Federation, Engineers Australia, Construction Skills Queensland as professional development courses

Figure 3: SBEnrc research outcomes dissemination strategy

Conclusions for Industry

This SBEnrc research project has provided the Australian transport infrastructure industry with a set of milestones for implementation based on current roles of the different organisations that can influence the uptake of integrated project environment processes and technologies.

This project found that:

1. The industry needs clear leadership to embark on those activities that will lead to industry transformation promised by IPD and BIM. The Transport and Infrastructure Council is in the best position to take this leadership role.
2. This leadership needs to be supported by industry engagement through active collaboration, discussion and interaction with Australian industry peak bodies, and with a coordinated program of pilot projects across Australia.
3. There is a need to develop and test new standards and metrics that can be applied to pilot projects to monitor implementation of the new processes and technologies. These should be reflected in modified contractual frameworks.
4. IPD principles can be applied to different types of contracts already in use, provided that new considerations are implemented to ensure clear and consistent rules, across the different project phases.
5. The construction industry needs to increase coordination and collaboration across knowledge providers and industry support initiatives, in order to reduce the skills gap. Efforts such as those of APCC-ACIF and SBEnrc should be supported and recognise the benefits of a stronger link between industry and applied research, as well as between industry entities.
6. Industry dissemination strategies should include a three tier approach in order to ensure that relevant roles are included and receive adequate information and attention.

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Acronym list:

ACA - Australian Constructors Association

ACIF - Australia Construction Industry Forum

APCC - Australasian Procurement and Construction Council

FMA - Facility Management Association

MBA - Master Builders Australia

PTI/IPT - Project Team Integration/Integrated Project Team

TAFE - Technical and Further Education

TISOC - Transport and Infrastructure Senior Officials' Committee

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For more detailed information about this research please refer to the following reports available at www.sbenrc.com.au (Project 2.24)

- Sanchez AX, Kraatz JA and Hampson KD, 2014. *Integrated Project Environments: Briefing Report for Industry.* Perth: Sustainable Built Environment National Research Centre
- Sanchez AX, Kraatz JA and Hamspon KD, 2014. R*esearch Report 1: Towards a National Strategy.* Perth: Sustainable Built Environment National Research Centre
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