

Article

Digital Modeling, Integrated Project Delivery and Industry Transformation: An Australian Case Study

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Abstract: This research is focused on realizing productivity benefits for the delivery of transport infrastructure in the Australian construction industry through the use of building information modeling (BIM), virtual design and construction (VDC) and integrated project delivery (IPD). Specific objectives include: (I) building an understanding of the institutional environment, business systems and support mechanisms (e.g., training and skilling) which impact on the uptake of BIM/VDC; (II) gathering data to undertake a cross-country analysis of these environments; and (III) providing strategic and practical outcomes to guide the uptake of such processes in Australia. Activities which will inform this research include a review of academic literature and industry documentation, semi-formal interviews in Australia and Sweden, and a cross-country comparative analysis to determine factors affecting uptake and associated productivity improvements. These activities will seek to highlight the gaps between current-practice and best-practice which are impacting on widespread adoption of BIM/VDC and IPD. Early findings will be discussed with intended outcomes of this research being used to: inform a national public procurement strategy; provide guidelines for new contractual frameworks; and contribute to closing skill gaps.

Keywords: building information modeling (BIM); virtual design and construction (VDC); integrated project delivery (IPD); transport infrastructure; Australia; procurement

1. Introduction

Traditional delivery models used in transport infrastructure construction have been described as hierarchical, fragmented, linear and prone to promoting adversarial behavior across the supply chain [1]. Integrated project delivery (IPD) however “**is a project delivery approach** that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to reduce waste and optimize efficiency through all phases of design, fabrication and construction” [2]. It is thus a business model for the integration of the design and construction stakeholders which is not tied to a specific contract type or technologies, but is rather a set of principles that can be applied to a range of circumstances [3,4].

Importantly IPD leverages digital information technologies such building information modeling (BIM), and virtual design and construction (VDC) to unlock its potential for industry transformation [5]. Succar (2009) highlights that IPD is the final stage (and goal) in the maturity of BIM [6]; with IPD offering the potential to produce designs that are optimized for quality, aesthetics, constructability, affordability, and timeliness by involving key expertise from across the supply chain in the early stages of a project, where changes have the highest impact on project outcomes [7].

In Australia, significant issues have been highlighted using traditional delivery methods (differences with IPD have been described by AIA [3]) including: wasted effort (10%–15% of unnecessary cost and wasted time) [8]; numerous variations due to poor documentation (60%–90% of all variations) [9]; inefficiencies due to lack of communication and interoperability (5%–10% of construction cost) [10]; and general cost and time overruns which add substantially to project costs [11]. Past research has highlighted potentials for productivity improvements through the adoption of BIM/VDC [12]. This is a central motivation for this research specifically with regards to the delivery of transport infrastructure in the Australian construction industry through the use of BIM/VDC and IPD.

Australia-wide adoption of BIM/VDC across the supply chain could enhance industry productivity by up to 9% [13] and provide potential savings of up to AUD12 billion through improved documentation and information transfer alone [9]. Additionally, while the cost of implementing new technology is often seen as a barrier to adoption, the return on investment for BIM implementation has been reported as high as 500% [7].

The industry need for significant structural reform to realize the potential for productivity improvement from digital modeling is well documented [14–17]. The Australian Built Environment Industry Innovation Council (BEIIC) identified BIM as an important emerging and transformative enabling technology, with the potential to streamline processes throughout a building’s lifecycle [17]. BEIIC noted that the widespread adoption of BIM could enhance productivity across the industry and in turn have a significant positive impact on the Australian economy. This research addresses three of the key findings of that report: informing a national public procurement strategy; providing guidelines for new contractual frameworks; and addressing skill gaps. This is being undertaken in the context of cross-disciplinary theories of meta-governance and technology diffusion to shed light on overarching issues, and inform other technologies and fields of research.

The aim of this research is thus to inform institutional arrangements, business advice and support systems which enable digitalization in this industry, and provide a foundation for the more effective management of industry issues relating to project delivery and industry productivity.

The research focuses on the impact of the institutional environment in Australia on BIM/VDC uptake in the context of multi-actor engagement and the role of lead agents. From this perspective it also investigates Australian procurement and delivery frameworks and how they foster or inhibit integrated project delivery.

A cross country comparison has been undertaken with Sweden. Such comparison can be based on either the most similar or most different research design. In the later, the countries selected are similar in many respects but different in relation to the variables being studied, therefore controlling those variables that are similar across the two countries for it is assumed that the similarities do not provide an explanation for the differences that are observed [18]. Sweden was selected for comparison to Australia because both countries can be regarded as similar in many respects, but are different in relation to the variables under consideration in this study. There is a long tradition of research comparing Australia and Sweden. Both are small countries (population-wise) with similar levels of economic development (advanced Western economies) and democratic political systems, and both have fairly high levels of dependence on resources. However, Australia is a typical Anglo-Saxon competitive market economy and Sweden is a coordinated market economy [18]. The countries differ in relation to this study in terms of their level of inter-firm collaboration and the close relationship of large contractors with knowledge brokers and providers: Swedish contractors have close relationships with knowledge providers and brokers such as universities and research institutions [19]; the Swedish transport organization (Trafikverket), and design and construction firms have significant level of investment in the implementation of BIM in transport projects such as the Stenkumla-Dunsjö developed in collaboration with WSP [20,21]; and the Swedish education system has a stronger orientation towards training in engineering, systems, manufacturing and computers when compared to Australia, providing Sweden with an important source of graduates with technical expertise [18].

2. Research Approach

In 2009, the Australian Cooperative Research Centre for Construction Innovation (CRC CI) developed *National Guidelines for Digital Modelling* [22] addressing BIM and IPD uptake in the delivery of building projects. These guidelines highlighted the disruptive rather than evolutionary nature of required change, and the need for strong leadership at a national industry-wide level to meet identified challenges. The CRC CI framework focuses primarily on technical application of BIM in an integrated project environment.

This research addresses the significant knowledge gap between current technical capabilities and those needed for the uptake of digital modeling specifically in the delivery of infrastructure projects in Australia. Currently, we do not have a thorough understanding of how to achieve better technology uptake, or the required transformation in this sector. We also have only limited understanding of how the institutional environment and support systems facilitate or impede industry transformation. This research draws on the BIM study framework developed by Succar [6] that identifies technology, process and policy as interlocking fields, with two sub-fields each, players and deliverables and establishes network-based integration as the last stage of BIM maturity. Whilst other barriers (such as the conflict between “messy” discussion [23] and formal BIM processes) are recognized, they remain outside the boundaries of this current research.

This research thus aims to identify characteristics of the Australian institutional and business support environment which may act to limit uptake, and compare with other countries where greater uptake is evidenced. This will draw on organizational research that takes account of the specific characteristics of firms and industry and recognizes: the influence of a dynamic business environment; the importance of gaining and understanding of these phenomena; and the need for methods that will take into account the holistic, contextual dimensions of the environment in which managers operate [24].

The research questions being addressed by this research are:

- (I) Are there multi-actor engagement models that can support BIM/VDC uptake, and if so, do current forms of contract and business processes in Australia align with these processes and technologies, and the adoption of integrated project delivery to maximize productivity benefits?
- (II) Is there an organizational lead agent in Australia coordinating BIM/VDC strategy development and implementation for the sector, and if not what is the impact of consequent fragmentation on:
 - (a) behaviors amongst those involved;
 - (b) project delivery frameworks;
 - (c) access to skilled labor and business capability development programs.

Prior research suggests that such environments play an important role in influencing the process of industry transformation [25], and problems of industrial transformation have become increasingly complex, requiring new arrangements involving the coordinated meta-governance of industry sectors [13,26,27] (Metagovernance refers to the need for public organizations to exercise some control over devolved and decentralized decision-making organizations (whether hierarchical, networked or governed by the market) [15].):

- **Network models of multi-actor engagement**—Such models [26,28] enable input in industry strategy development from a wide range of economic actors including government, industry associations, training bodies and research institutions [29]. This requires models of decision-making which are decentralized and involve “reflexive rationality” which arises from negotiation and steering for the purpose of coordinating economic behaviors in the pursuit of common purposes. This will be investigated in the context of issues of collaboration not previously facilitated by traditional procurement forms, and which do not embody an open multi-disciplinary approach with the early engagement of contractors and sub-contractors. This problem is well recognized within the UK [30] and Australia [31]. The development of solutions to problems of industry change and technology uptake might depend on the extent to which meta-governance institutional arrangements are reflected in procurement arrangements and project delivery;
- **An organizational lead agent coordinating delivery frameworks for analyzing uptake**—Responsible for coordinating delivery frameworks in the implementation of strategies which mobilize stakeholders to pursue common goals. Prior research shows that institutional environments in which there is a coordinating agent “laying the ground rules” for the sector is critical if coordinated transformation is to occur [12,26,27,32,33]. As such, it is necessary to have a steering agent responsible for providing overall guidelines and frameworks, including a common communication platform around performance and productivity benefits. This includes three elements: (I) the development of *achievable mandates* with government agencies taking a steering role in mandating BIM and VDC deliverables for their program of works; (II) the need

for *national benchmarks* as a baseline from which performance can be reported and understood; and (III) a *performance reporting framework with common metrics* to enable effective tracking of benefits and measuring return on investment to the various parties [34–37]. Given limited current communication frameworks we would expect the role of lead agents in coordinating the development and implementation of these to be critical in achieving industrial transformation and associated productivity gains.

Prior research has also shown that skills development [38] and business capability development are critical for achieving industrial transfer. Knowledge intermediaries can play a crucial role in influencing industry innovation through education, training and skills, and advisory components of technology diffusion programs [13]. Such intermediaries (in addition to the more traditional providers such as universities, the VET sector and industry associations) can facilitate industry change by ensuring that firms have access to skills, new knowledge and new knowledge networks, as well as ensuring that firms understand the organizational changes required to introduce new technology [13]. In addition, education and training programs and firm capability building are critical to overcome the forces of path dependency which result in industry sectors and firms continuing with existing inferior technology options, even when faced with superior new technological opportunities [39,40]. Industries and firms can also be hindered by embodied structural inertia arising from routines that encourage exploitation of existing competences, rather than exploration of new technologies and competencies [41–43]. In the context of transport infrastructure delivery, the industry is dominated by SMEs who face barriers to investment in new technology in terms of both time and financial resources, given that new technologies are disruptive to business processes and require the development of new organizational capabilities. In this context, the role of external knowledge intermediaries in supporting SMEs is vital. Additionally skills development is not adequately addressed through traditional educational mechanisms, in part due to the rate of change of the technology and the inherent resistance in the industry to changes in work practices. International examples exist worthy of further investigation in the Australian context [44].

2.1. Research Methodology

Research activities included: a review of the academic literature; a review of industry documentation in Australia; semi-formal interviews in both Australia and Sweden; and a cross-country comparative analysis to determine factors affecting uptake.

A review of the academic literature was undertaken in the fields of BIM/VDC, IPD, coordinated meta-governance and technology diffusion theories. Meta-governance is considered pertinent in line with the need for formal public organizations to exercise some control over devolved and decentralized decision-making organizations [45] in order to maximize opportunities for industry-wide productivity improvements. Technology diffusion, that is, the acceptance and spread of new technology in a market or user community [46], is being considered in terms of mechanisms to improve the dissemination and uptake of BIM and IPD across the industry.

Industry documentation included standard contract and procurement guides from different road and transport authorities within Australia in order to establish the state-of-practice. Available international best practices guides and model contracts developed for BIM/VDC and IPD in infrastructure construction projects were also analyzed.

2.1.1. The Interviews

Twenty-one semi-formal face-to-face or video conference interviews were undertaken in both Australia and Sweden in late 2013. Interviewees were selected once the research team had identified potential organizations (and roles) for participation. Organizations and roles targeted for interview in both Australia and Sweden included: clients, asset owners and procurement managers; design BIM managers; contractor project managers; supply chain, technical and industry experts; and representatives of industry-based associations, in order to ensure a cross section of views. The selection criteria included having: (I) a key management role within the transport infrastructure construction supply chain; (II) access to documents that could be used as basis for case studies and document analysis; (III) knowledge and experience related to the use of BIM/VDC in infrastructure construction projects; and (IV) availability to participate.

In-depth semi-formal interviews following a relatively unstructured pattern using the *tell me about* approach for investigating business decision-making activity, allowing respondents to describe opinions and views. Benefits of this method included: (I) covering a wide area of interest, allowing the researcher to become familiar with the areas of interest as the research progresses; (II) identification and exploration of key issues as they are revealed due to the open-ended nature of the interview protocol; and (III) allowing opportunity for further probing and examining until mutual understanding is reached [24].

Interviewee questions were developed based on the research questions and the findings of the review of both the academic literature and industry documentation. Some questions were generic across all interviewees to enable cross-organizational analysis and others were role-specific, to provide a richer in-depth description of the processes being researched. This is providing an in-depth understanding of the influences on managerial decision making processes from an insider perspective [24]. A number of methods proposed in the literature [37,38] were considered. Due to the small research team size different investigators are assigned to each of the two countries and a third person not involved in the actual interviews undertook reviews and coding. Interview questions were refined from the following:

- *Network models for multi-actor engagement in BIM/VDC uptake*: including specific questions relating to: which economic agents are impacting on the industry and how industry strategy has developed; whether there is multi-stakeholder engagement in which organizations collaboratively develop industry strategy; if key organizations work in isolation or whether they negotiate and modify their behaviors in communication with other key organizations and in pursuit of common goals; and if there is information sharing, appropriate risk sharing and open communication. Particular attention was given to procurement arrangements for the purpose of determining whether current forms of contract and business processes are aligned with integrated project teams and multi-actor engagement.
- *Organizational lead agent coordinating delivery frameworks*: including whether these agents are coordinating technology uptake; whether the institutional environment is fragmented, and whether this leads to inconsistent and conflicting behaviors amongst economic actors; or if coordinated, whether this facilitates the development of a common agenda and complementary behaviors.
- *Business support systems*: relating to technology uptake and organizational innovation including: types of programs in place; how are they delivered; the role of knowledge

intermediaries in coordinating the system of business support and skill development for the industry; and how access to skilled labor and business capability development programs is affecting the ability of firms to adopt BIM/VDC technologies.

- *Role of knowledge intermediaries:* in education, training and business advice and support including the role of research institutes, training bodies, professional organizations and large contractors in skill development; and access to skilled labor and development programs
- *Context and practical issues:* of IPD and BIM/VDC including: clients leadership/role during early project phases to encourage uptake; relevant contract clauses for the use in transport infrastructure projects; best-practice case studies; and the value-add from BIM/VDC.

2.1.2. Analysis of Data

A significant amount of data has been gathered from the review of academic literature and procurement documentation, and from interviews. This has been compiled into dominant themes (through the identification and application of keywords) pertaining to the key areas of investigation, then coded. To counter possible researcher bias, different researchers undertook this task for: (I) the literature and documentation; and (II) the interviews. For interview data the frequency of the response was recorded in an effort to identify dominate issues. Verification of findings has been achieved through the triangulation of data from multiple sources throughout the data analysis phase [47].

Data has been analyzed both with-in each country and then between Australia and Sweden [48], with each investigator developing preliminary hypotheses from their respective data sets, exchanging these with other team members, and searching for patterns within the data. Analysis has been undertaken in order to both contribute to the academic theory in this field, and also provide practical industry-based guidance, specifically relating to coordinated meta-governance and lead agent roles.

Given the small sample group, generalizations from the data are problematic. The research team has aimed to counter this to some extent though through the selection of experienced and knowledgeable interviewees in key positions in influential organizations.

The cross-country comparison allows for the testing of the general theories through comparative checking. The research team has analyzed findings to identify variables that are potentially influencing the uptake of BIM/VDC, for example between the institutional environment in Australia and Sweden at the macro-level.

3. Findings and Discussion

This research has revealed gaps between current and best-practice in Australia which is impacting on the adoption of BIM/VDC and IPD. This has been based on: (I) a review of documentation from Australia (both nationally and from three States), the UK and the USA; (II) a review of academic literature in the fields of BIM/VDC, IPD, meta-governance and technology diffusion; and (III) twenty-one semi-formal interviews.

A cross-country analysis is being undertaken between Australia and Sweden to determine how the institutional environment and business support systems vary between these two nations and the extent to which different institutional arrangements and support systems are associated with superior uptake of BIM/VDC technology in transport infrastructure construction.

3.1. Review of Documentation

The review of documentation was undertaken based on 14 of the key topics outlined by the 3xPT Strategy Group Integrated Project Delivery (IPD) Principles for Owners and Teams report [49]. Documents reviewed included standard contract agreements, manuals and guidelines issued by: NATSPEC, Queensland Transport and Main Roads (QTMR), New South Wales Roads and Maritime Services (NSW NRMS), Main Roads Western Australia (MRWA) in Australia; UK's Chartered Institute of Building (CIOB) and the AEC (UK) Committee; and the American Institute of Architects (AIA). Contract documents reviewed included those focusing on Design and Construct (D&C), Early Contractor Involvement (ECI) and General Conditions of Contract documentation which are publicly available or provided by the respective organizations.

The particular focus of the review was on: (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. It compared the suitability of each organization's approach and provided recommendations as to how current practices could be modified. Recommendations have been based on: (I) required modification/expansion of current practice; and (II) new considerations. Key recommendations will be contract-based, and cross-referenced with academic theories derived from the literature review in order to develop links between industry concepts and the theories of coordinated meta-governance and technology diffusion. This in turn will be considered in the context of findings from the semi-formal interviews.

3.2. Review of Literature

From the perspective of the academic literature: the concept of coordinated meta-governance has guided recommendations for better institutional frameworks and contractual arrangements that underpin more collaborative delivery models; and technology diffusion theory highlights steps needed to secure a better skilled workforce and to assist business to absorb and implement new knowledge and technologies. Learnings based on these approaches can be tailored to the transport infrastructure construction industry to contribute to the widespread adoption of IPD and BIM/VDC technologies without marginalizing small and medium enterprises.

It is further highlighted that the challenges of industrial transformation have become increasingly complex due, in part, to the speed of change of enabling technologies, and therefore require new arrangements involving the coordinated meta-governance of industry sectors.

IPD involves integrated teams composed of key project stakeholders, early engagement, open collaborative communication, multilevel decision making, early contributions of a variety of knowledge and expertise, open sharing of information, collective management, collectively managed and appropriately shared risk. This contrasts to the hierarchical, fragmented, linear, individually managed orientation of traditional project delivery styles [7]. This suggests that the industry change and technology uptake needed for a widespread use of BIM/VDC in transport infrastructure delivery might depend on the extent to which procurement arrangements and IPD are characterized by meta-governance institutional arrangements. While collaborative decision making and multi-actor engagement is necessary to achieve industrial transformation, it is also necessary to have a steering agent responsible

for providing a common communication platform around performance and productivity associated with technology uptake [12]. Given limited current communication frameworks for understanding delivery outcomes for BIM/VDC in the delivery of transport infrastructure, we would expect the role of lead agents in coordinating the development and implementation of frameworks across the sector to be critical in achieving industrial transformation and associated productivity gains.

In addition to developing guidelines relating to the institutional mechanisms necessary to achieve industry-wide uptake of new technologies, prior research has shown that skills development and business capability development are critical for achieving technological transfer across the industry [1,5,8,9]. In the context of infrastructure delivery, the role of knowledge intermediaries will be particularly important as the industry is dominated by small and medium sized enterprises (SMEs) [10] who face barriers to investment in new technology in terms of both time and financial resources, given that new technologies are disruptive to business processes and require the development of new organizational capabilities [11].

3.3. From the Interviews

Thirty-two themes were identified from an analysis of the Australian interviews. Twenty-eight themes were identified from the Swedish interviews. Twenty-one common themes were found and grouped into four umbrella topics:

- *Barriers, challenges and benefits*: this group of themes will provide valuable insights gathered from expert interviewees, which will inform the overall narrative and findings. This includes risk, value for money, industrialization and mass customization and standardization.
- *Multi-actor engagement*: as characterized by decentralized decision-making arising from negotiation and steering for the purpose of coordinating economic behaviors for a common purpose). The key issues identified by Australian and Swedish interviewees related to cultural, management and economic issues, with comments also on collaboration. Apart from the need to undertake cultural change, Swedish interviewees provided a greater level of discussion on each of these issues.
- *Organizational lead agents*: the need to have an agent who is responsible for providing the overall operational guidelines and frameworks, underpinned by a common communication platform around performance and productivity associated with technology uptake is emerging as a key issue. In this role, meta-governance allows public authorities to mobilize the knowledge, resources and energies of a host of public and private actors while retaining their ability to influence the scope, process and outcomes of networked policy-making [6]. Industry fragmentation has been identified as a barrier to achieving this in Australia [33]. Several organizations provide guidance in different arenas, for example: Engineers Australia for general awareness, legal and insurance issues; SBEnrc and previously CRC for Construction Innovation for technical and business related issues; buildingSMART for technical guidance; and the Australian Construction Industry Forum (ACIF), the Australian Procurement and Construction Council (APCC) and the Civil Contractors Federation of Australia (CCF) in additional niche areas, with no overarching body providing industry-wide initiative. In Sweden Trafikverket, and in the UK the Government Construction Strategy [30] provide such leadership. Key issues

discussed by interviewees relevant to this theme included client drivers, mandates, standards, pilots, and metrics.

- *Knowledge intermediaries*: play a role in education and training for industry skill development as well as developing a firm's ability to understand, analyze and acquire knowledge from external sources. Such services facilitate industry change by ensuring that firms: have access to skills, new knowledge and associated networks; and understand the organizational changes required to introduce new technology [13]. They can have a powerful influence on the speed of diffusion and uptake of new products and services. These organizations also play active roles in the diffusion process, including: (I) support in decision-making of whether to adopt or not; (II) as a specification writer or standard setter; and (III) as an evaluator of the technology once it is in the market [50]. Key areas identified from interview related to diffusion and uptake; skills; productivity; asset management and SMEs. Significant differences are emerging between Australia and Sweden. In Australia industry associations are a primary avenue for up-skilling; whilst in Sweden there are stronger links between clients, contractors and universities.

3.4. Early Conclusions—Towards a National Strategy

The need for a steering agent to facilitate industrial transformation in Australia has been highlighted as an early finding of this current research. In this context the term “peak body” covers non-for-profit umbrella organizations 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 organizations in the UK and USA [51]. These organizations may also be defined as carrying out similar roles to that of System Integrators described as 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 [52].

This current research is focusing 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. It aims to identify those players which form Succar's Policy Field [6]. These organizations focus on *preparing practitioners, delivering research, distributing benefits, allocating risks and minimizing conflicts* within the industry and play *pivotal preparatory, regulatory and contractual roles in the design, construction and operations process* [6].

To this end, mapping the relevant industry peak bodies in Australia and Sweden has provided evidence for the identification of the role and impact of different organizations on the uptake of new information technologies in the transport infrastructure industry. This has also led to the development of a roadmap for adoption based on current activity and showing the domino effect that each action would have on the industry.

In addition a series of recommendations are being finalized to inform a national strategy which will be proposed for adoption to lead transport agencies in Australia. Key issues considered relevant to such a strategy include:

- (I) The development of such a strategy will require the leadership and coordination of lead agent and engagement with lead industry associations is important in the dissemination and industry leadership;
- (II) The main transport infrastructure clients are state and territory government agencies. As such, these organizations are in a unique position to influence the uptake of new technologies and processes;
- (III) Pilot projects aim 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 to develop a pipeline of coordinated actions;
- (V) Building consensus on standard performance indicators and metrics to proof the business value of BIM and IPD in terms of project, business and industry-wide productivity gains;
- (VI) The development of national standards provides a framework for a nationally consistent approach for uptake that reduces macro-economic burden of adoption and increases productivity.

Future research is also required, for which funding is currently being sought, for; (I) follow-up investigations with additional interviewees to enable generalizations to be drawn from findings; and (II) investigations at a more nuanced level into project-team interactions across interorganizational networks.

These findings are now being consolidated and disseminated to both an academic audience, and to industry to advance the practical uptake of BIM/VDC and IPD in Australia through three tiers of engagement: firstly at the level of Commonwealth and State government ministers; secondly at the level of strategic decision-makers in both government and industry; and thirdly to project, program and procurement managers and engineers more broadly. A range of dissemination methods will be used including targeted case-studies, audio-visual presentations and contributing content for continuing professional education courses delivered in conjunction with key nation-wide industry associations.

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Author Contributions

Each author has contributed to the refinement of this research agenda; development of the research protocol; analysis of interview findings and preparation of this and other academic and industry publications. Additionally Adriana X. Sanchez and Keith D. Hampson undertook interviews to gather data for analysis, in Australia and Sweden respectively.

Conflict of Interests

The authors declare no conflicts of interest.

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