Document Review
Research Report 2
SBEnrc - Integrated Project Environments
Leveraging Innovation for Productivity Gain Through Industry Transformation (Project 2.24)

This documents aims to compare state-of-practice vs. best practices in contractual arrangements suitable for IPD and BIM. At this point it only includes documents from English speaking countries.

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Acronyms

AIA - American Institute of Architects

AIA AC - American Institute of Architects Contract Addendums

BIM - Building Information Modelling

BIM-DDE - Building Information Modelling and Digital Data Exhibit

BMP - BIM Management Plan

BIM-PF - Project Building Information Modelling Protocol Form

CIOB - Chartered Institute of Building

CIOB CPC - Complex Projects Contract drafted by UK's Chartered Institute of Building

CMc - Construction Manager – Constructor

DBB – Design-Bid-Build

D&C – Design and Construct

DMS - Document Management System

DWG – DraWinG (binary file format used for storing two and three dimensional design data and metadata)

ECI – Early Contractor Involvement

FTP - File Transfer Protocol

GIC-DPD - AIA Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents

IFC – Industry Foundation Classes

IPD – Integrated Project Delivery

LOD - Level of Development

MRWA - Main Roads Western Australia

NSW RMS - New South Wales Roads and Maritime Services

PCIP - Principal Controlled Insurance Program

PFD - Program for Design

QTMR - Queensland Transport and Main Roads

RAP - Risk Adjusted Price

SWTC - Scope of Works and Technical Criteria

VDC - Virtual Design and Construction

WIP - Work in Progress

Executive Summary

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[1]. This report summarises the findings of the document review carried out based on 14 key topics outlined by the 3xPT Strategy Group Integrated Project Delivery (IPD) Principles for Owners and Teams report[2]. Documents include contract agreements, manuals and guidelines issued by: Queensland Transport and Main Roads (QTMR), New South Wales Roads and Maritime Services (NSW NRMS), 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 cover between 11 and 13 topics. However, the key difference between these organisations is: (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 Building Information Modelling (BIM)/Virtual Design and Construction (VDC).

The discussion section is used to analyse these two issues, compare the suitability of each organisation's approach and, where relevant, provide recommendations as to how current practices could be modified based on the aforementioned analysis. The recommendations are then divided into (i) Modification/expansion of current practices; and (ii) New considerations.

Key recommendations for consideration include:

1. **Use of clearly defined Levels of Development (LOD)[3]** 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 terms of responsible roles, submission dates, among other.
2. Procurement managers to consider the benefits of including **subcontractors in the project team** and their contribution to the design 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 clauses to savings** produced by changes to the design or project delivery methods can create a clear incentive for more innovation, collaboration and time/cost efficiency gains.
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 the with facility/asset management system requirements to allow the integration of data throughout the supply chain.

[1] AIA (2007).

[2] 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.

[3] 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, 2013c).

5. The risk of non-performance should be shared among the participants equally. If participants are not comfortable doing so, **risk apportioning should be agreed upon** in the contract agreement. 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 where each owner is responsible for element at the phase and LOD defined in the BIM Execution/Management Plan.
6. An **integrate project coordination role** is required to coordinate, facilitate and direct the integrated team.
7. Prepare a **BIM Protocol addendum** to the contract agreement that redefines terms, procedures and metrics and can be added to BIM-enabled projects. File Transfer Protocols and Common Data Environments can also facilitate the coordination and delivery of projects under IPD principles and using BIM/VDC. 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 contracts offer the best integrated collaboration model, with all relevant participants being closely involved in the project development from early stages. This model can use relationship management plans, collaboration standards and regular meetings with all relevant stakeholders to maximise the efficiency and quality of the works. Additionally, ECIs 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.

Finally, the documents were also reviewed in terms of educating and up-skilling 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.

1. Introduction

This document presents the findings of activity (ii) 'desktop research' as described in the Research Protocol:

> *Desktop research activities will focus particularly on procurement arrangements and integrated project delivery models. These activities will mainly comprise the analysis of industry documentation such as standard contract and procurement guides from different road and transport authorities within Australia and Sweden[4] 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 will also be analysed*.

Each template contract will be analysed using key topics and questions outlined by 3xPT Strategy Group (Integrated Project Delivery: First Principles for Owners and Teams, 2007) spearheaded by Martin Fischer (CIFE, Stanford University) as point of departure. *The 3xPT Strategy Group is a collaboration of the Construction Users Roundtable (CURT), the Associated General Contractors of America (AGC), and the American Institute of Architects (AIA), formed in 2006 to become a credible voice representing the three organizations on matters regarding industry transformation* (3xPT Strategy Group, 2007).

Based on the scope of the present project and key challenges identified in the literature review, the research team selected 14 of the original 32 topics to expand the research based on standard contract templates across the Australian transport infrastructure construction agencies: 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 (Figure 1) (Sanchez A. X., Lehtiranta, Hampson, & Kenley, 2013).

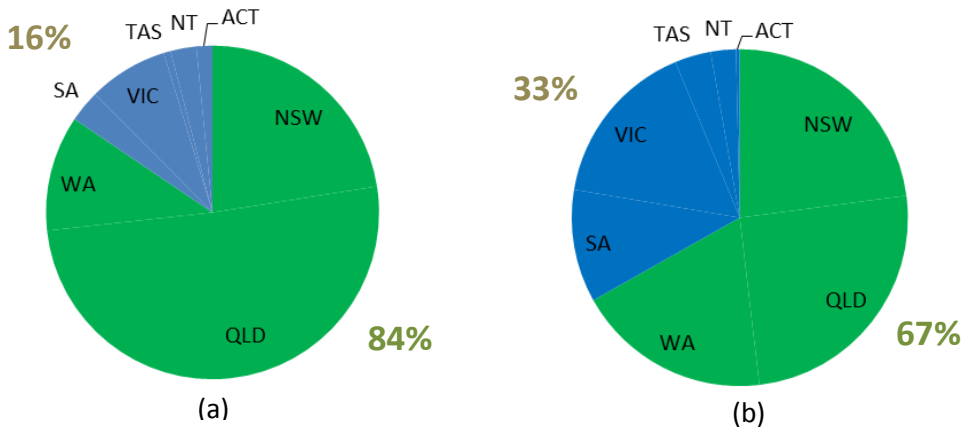


Figure 1. (a) total road expenditure by state/territory, by level of government, 2011-12 prices — State/Territory; (b) total road length by state/territory (2011-12) (BITRE, 2013)

[4] Most of the Swedish documents are only available in Swedish language. Therefore, the Swedish document review will be carried out by two Visiting Academics from Chalmers University.

The selected topics are:

1. Service Scopes
2. Subcontracts
3. Changes
4. Outcome/Overall Performance Metrics
5. Risk Management/Distribution
6. Collaboration/Coordination
7. Selection Process and Criteria
8. Technology Protocol
9. Information Management
10. Information Hand-over/As-built Documentation
11. Information Security/Confidentiality
12. Contract Model
13. Compensation
14. Risk/Insurance

3xPT Strategy Group (Integrated Project Delivery: First Principles for Owners and Teams, 2007) also outlines a series of questions that should be answered by contract managers under each topic. These are:

1. **Service Scopes**
   - What does each company do and deliver on the project?
   - When are the services delivered?
   - What are the performance criteria for each service/company?
   - How, when, and how often is the performance tracked?
   - How many design versions will be produced?
   - What is included in a design version (just architectural scope, all design disciplines, full building definition plus construction schedule, etc.)?
2. **Subcontracts**
   - What other key parties should/must be involved?
   - What expertise or capacity is critical in addition to the expertise and capacity available from the main project participants?
   - When and how is that expertise and capacity brought into the project?
   - How are these subs engaged in the project? What performance expectations are made explicit? How is the performance tracked?
3. **Changes**
   - What changes are part of the scope or should be expected by the participants?
   - How are changes in scope, schedule and organisation handled?
   - What are likely sources of changes?
   - What changes have detrimental impact? Are there changes with positive impact?
   - How can changes be minimised?
4. **Outcome/Overall Performance Metrics**
   - What are overall project outcome/performance metrics?
   - What are the cost-related performance metrics for the work (e.g., initial cost, lifecycle cost, target cost? How are the budget/costs established?
   - Who owns cost contingencies (who, how much, for what)?
   - What are schedule performance metrics (e.g., duration, milestones)?
   - What are the sustainability and life cycle goals for the project?

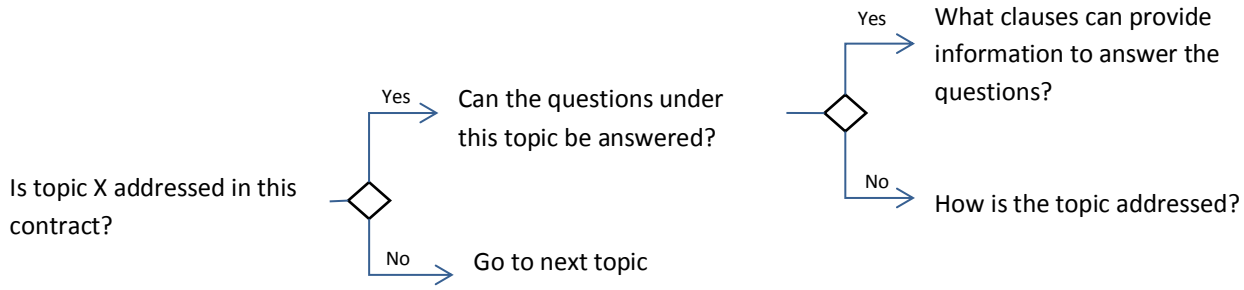
- What do the users expect from the facility?

5. **Risk Management/Distribution**
   - How are the risks managed?
   - Who assumes which risks when? How?
   - Are all the risks pooled and managed as pooled risks, or is there a "divide and conquer" approach to risk management?
6. **Collaboration/Coordination**
   - How is the collaboration between stakeholders organised?
   - Which stakeholders are coordinating what when with whom? How often? With what coordination methods?
   - How are the coordination activities planned?
7. **Selection Process**
   - How are team members (companies, individuals selected)?
   - What *must have* and *nice to have* criteria are used?
8. **Technology Protocol**
   - What are there *must-have* tools? Must-master tools?
   - What commitments are made/needed with respect to tool use and following information protocols (see questions below)?
   - What personal and organisational expertise is needed for these tools?
9. **Information Management**
   - How is information represented?
   - How is information shared?
   - How is information updated?
   - What is the role of digital models (building information models)?
   - How is the quality of information ascertained?
   - Who owns what information when?
10. **Information Hand-over/As-built Documentation**
    - What information is handed over after each phase? What are logical hand-over points?
    - In what format is information handed over?
    - Who controls, warrants the quality (accuracy, completeness) of the information handed over? How is quality of information hand-over checked?
11. **Information Security/Confidentiality**
    - Who manages information security (for each company, for the project as a whole, by issue, by discipline, project phase, by project sub-scopes)?
    - How does each party establish what information is confidential?
    - How are information confidentiality and collaboration reconciled?
12. **Contract Model, Compensation and Risk/Insurance**
    - What contracts and business deals, arrangements, and agreements will support the project scope, goals, and work of the various companies?

Topics not chosen for this review might be investigated in future research.

2. Methodology

Each document will be studied individually following the structure shown below (where 'X' corresponds to the topic number from the list above):



The findings from the first level question will be presented in a binary comparative matrix as shown below, where if the answer is 'yes' a mark is made on the matrix (Y: found in specific contract document, G: found in General Conditions document) and an N is used to symbolised 'Not found'.

Table 1. Template comparative matrix. Acronyms stand for: Early Contractor Involvement (ECI), Design and Construct (D&C), Complex Projects Contract drafted by UK's Chartered Institute of Building (CIOB CPC), American Institute of Architects contract addendums (AIA CA).

Contract / Topic	QTMR		NSW RMS		MRWA	CIOB CPC	AIA CA	AEC (UK)	NATSPEC
	ECI	D&C	ECI	D&C	D&C				
1. Service scopes									
2. Subcontracts									
3. Changes									
4. Outcome/ overall performance metrics									
5. Risk management/ distribution									
6. Collaboration/ coordination									
7. Selection process and criteria									
8. Technology protocol									
9. Information management									
10. Information hand-over/As-built									

doc.									
11. Information security/ confidentiality									
12. Contract Model									
13. Compensation									
14. Risk/Insurance									

Note: MRWA does not have an ECI contract template

Findings from the second and third level questions are summarised by topic in the Appendices and used as basis for the discussion, conclusions and recommendations.

3. Contracts and Guides

The following sections aim to provide background information on the contracts and guides to be studied.

3.1. Early Contractor Involvement (ECI)

This contract is similar to the Construction Manager – Constructor (CMc) contract, which has been argued to be particularly well suited for Integrated Project Delivery (IPD) and the use of collaborative digital technologies such as Building Information Modelling (BIM) and Virtual Design and Construction (VDC) (AIA, 2007).

Under this model, the contractor is included in the project's initial stage to develop the design and a detailed project plan with realistic time frames. The Risk Adjusted Price (RAP) is delayed for the delivery stage of the project, until all risks are assessed to a greater detail without the assumption of a "cost plus" amount. If the RAP is not agreed upon, the client can terminate the relationship and place it for public tender (CEIID, 2010).

ECI contracts are characterised by integrated planning, design and construction process with early contractor and consultant involvement, potential to incorporate innovative ideas and construction methods, and the client retaining a strong influence in the planning and design stage (CEIID, 2010). In Queensland, an ECI is described as a negotiated D&C contract with significantly more efficient use of resources during the tender phase (QTMR, 2009a).

The practical knowledge of experienced contractors can benefit road design at an early stage, allowing the client to address changes in approvals and land purchase that would otherwise have become lengthy, complicated or unfeasible (e.g. changes in road scope and alignment to reduce haulage and cost, which, if it were to be addressed after tender award, would require new approvals from local and national authorities) (Sanchez, Lehtiranta, & Hampson, 2014).

Other added benefits of ECI contracts are shorter delivery timeframes, reduced tender cost, targeted input from all participants and a balance between the benefits of Alliance and Construct Only models (QTMR, 2009a).

Existing examples in Australia of successful ECI contracts include the MRWA Great Northern Highway Kimberley ECI Project (AUD116 m value, 2007-2009), where the delivery model allowed for the maximisation of synergies with the contractors in a complex geographical area. The following D&C contract was based on the work done during the ECI (The Earth Mover & Civil Contractor Magazine, 2010). The Bruce Highway Upgrade (Cooroy to Curra) delivered by QTMR and Abigroup is another example of a successful ECI. The inclusion of contractors and designers in earlier planning phases led to savings of over AUD17 million from avoided mass-haul and approximately AUD100 million due to the cost reduction per cubic metre based on conservative estimates (Sanchez & Hampson, 2012).

The two stage process inherent to ECI contracts allows, on the one hand, targeted input from the client and greater influence on project direction with minimal impact on cost during the first stage. On the other hand, the second stage can be carried out through more traditional models (e.g. Construct Only) with less risk of conflict and expensive variations (QTMR, 2009a). Figure 2 shows the procurement process used for the Bruce Highway Upgrade (Cooroy to Curra) ECI while Figure 3 shows the general structure outlined by Austroads' new procurement guide.

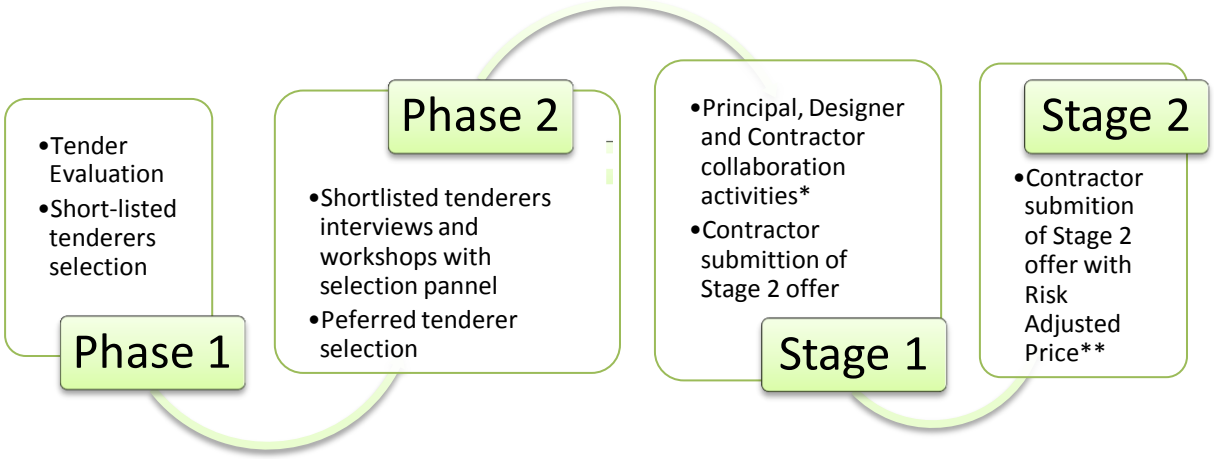


Figure 2. Procurement process used for the Bruce Highway (Cooroy to Curra) Section B ECI (QTMR, 2008)[5].

The analysis will focus on the documents: Standard Contract Provision Roads (Volume 6), Early Contractor Involvement (ECI) Contract: Introduction (QTMR, 2009c), Stage 0 – Establishment of the Contract (QTMR, 2009d), Stage 1 – Development of the Stage 2 Offer (QTMR, 2009e), Stage 2 – Construction of the Works (QTMR, 2009f), and NSW RMS Early Contractor Involvement Deed (NSW RMS, 2013d).

[5] *These activities include: plan the performance of the work under the contract, inputs to the detailed design for bulk earthworks, identify, mitigate, negotiate and apportion the risk in Stage Two, identify early works and implement construction as part of Stage One, and price the works for Stage Two (excluding early works).

** The Stage 2 offer with Risk Adjusted Price takes into account the risk apportionment negotiated in Stage One. The development of the RAP is built up progressively with the design and conducted on an open book basis. During Stage 2 the contractor also finalises the construction methodology, prepares construction documentation, and constructs the Works.

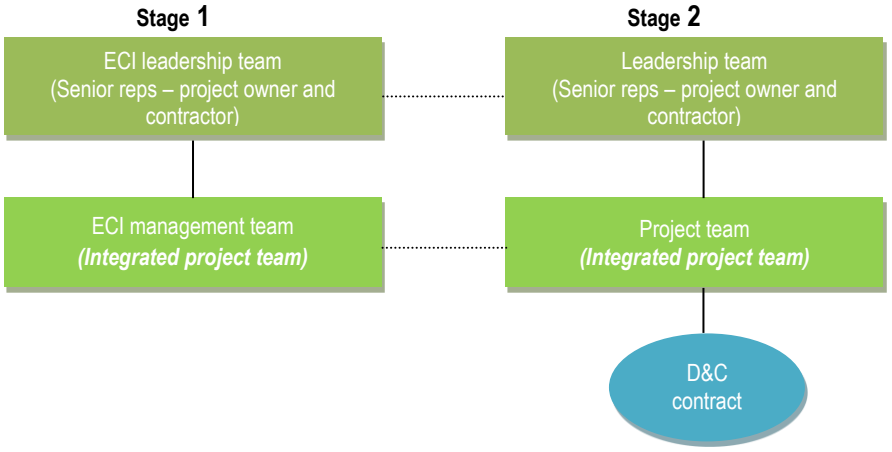


Figure 3. Structure of a typical ECI arrangement (Casey & Bamford, 2013).

3.2. Design and Construct (D&C)

In traditional D&Cs the client prepares a design brief, outlining the functions and key use requirements for the works. Then seeks tender for completion of the detailed design and construction of works (CEIID, 2010). These contracts are normally characterised by the contractor bearing the responsibility for the design consultants' contract, and the construction of the works. The client has limited control over the final design (NSW Government, 2008).

There are three common types of D&C contracts:

- *Traditional Design and Construct:* The contractor engages consultants to prepare the concept design, develop the design and prepare construction documentation (NSW Government, 2008)
- *Design Development and Construct:* Contractor's consultants develop the client's preliminary design (client determines the concept of the design); the contractor prepares the construction documentation and constructs the asset (NSW Government, 2008)
- *Design, Novate and Construct:* Single designer team used from concept stage to final design. The contract to the designer is transferred to the contractor (NSW Government, 2008).

In some cases, the establishment of the D&C can be preceded by a pre-qualification process. Al-Reshaid & Kartam (2005) argue that contractor and designer pre-qualification enables the client to differentiate between the attributes of the competing teams, thus pre-qualifying the team that best meet the needs of the client. An efficient pre-qualification process therefore involves the establishment of a standard for measuring and assessing the capabilities of potential tenderers (El-Sawalhi, Eaton, & Rustom, 2007). The pre-qualification is sometimes done through workshops that allow for early interaction between contractors and clients.

AIA (Integrated Project Delivery: A Guide, 2007) argue that although D&C contracts can be used for IPD, the use of this model often requires a certain level of design completion before tender. This and the fact that clients usually participate only in the earlier stages and then reduce their input and involvement later on, creates clear silos of responsibility and risk that can pose significant challenges for the use of IPD and BIM/VDC.

3.3. Complex Projects Contract Drafted by UK's Chartered Institute of Building (CIOB CPC)

The CIOB started as an informal group of Master Builders discussing union activity in 1834 in England and has now become an international organisation with members in every professional role in the built environment (CIOB, 2013c).

The Complex Project Contract drafted by the CIOB is comprised of three main parts: the Contract Agreement, the Conditions and the Appendices, which sets out the definitions, contract data, BIM protocol, details required in the working schedule, planning method statement and regular progress reports, and risk events (McKenna & Grudzinski, 2013).

This contract is argued to have the potential to be used for a variety of procurement strategies, including traditional D&Cs and more complex models that require a high degree of collaboration, needing *unusual provisions* such as allowance for notices and other documents being issued by email and File Transfer Protocol (FTP) (McKenna & Grudzinski, 2013). However, it was designed with a collaborative approach to the management, design, quality, time and cost (CIOB, 2013a).

Complex projects can be described as having one or more of these characteristics (Pemberton & Hakim, 2013):

- Incomplete design - completion of design takes place during construction
- Work involves complex mechanical, electrical and plumbing, services, more than one structure, a structure more than 15 m high and/or space below ground
- Multiple key dates and/or sectional completion dates
- Construction period of over twelve months
- More than one main contractor and/or more than 20 subcontractors.

3.4. The American Institute of Architects Contract Addendums (AIA CA)

The AIA was founded in 1857 as the professional membership association for licensed architects, emerging professionals and allied partners. This institute has issued over 100 contract documents that try to address the full spectrum of different scales of design and construction projects (AIA, 2013a). Among them, several documents are designed to be used in IPD and BIM/VDC projects. The present study will analyse the following documents: Integrated Project Delivery: A Guide (AIA, 2007), Building Information Modelling and Digital Data Exhibit (BIM-DDE) (AIA, 2013b); Project Building Information Modelling Protocol Form (BIM-PF) (AIA, 2013c); Digital Licensing Agreement Form (AIA, 2013d); Project Digital Data Protocol Form (AIA, 2013e); and the Guide, Instructions and Commentary to the 2013 AIA Digital Practice Document (AIA, 2013f).

The primary purpose of the Building Information Modelling and Digital Data Exhibit (AIA, 2013b) *is to initiate, at the outset of a project, a substantive discussion about the extent to which digital data and BIM will be utilized, and how digital data and models can be used and relied upon* (AIA, 2013f). This document is meant to be an attachment to the general contract agreement.

The Project Building Information Modelling Protocol Form (AIA, 2013c) and the Project Digital Data Protocol Form (AIA, 2013e) are meant to be used to document the decisions made by the project participants regarding the relevant protocols for the development and use of digital data and BIM. The separation of these documents is meant to allow the project participants to *first discuss and document their general expectations regarding use of Digital Data and BIM on the Project,* while

giving the opportunity to modify and adjust the protocols as necessary without having to *separately and formally amend each party's agreement* (AIA, 2013f).

The Guide, Instructions and Commentary to the 2013 AIA Digital Practice Document offers an analysis and discussion of the above mentioned documents, as well as alternative language for some of the articles (AIA, 2013f).

3.5. AEC (UK) Committee

The AEC (UK) Initiative was formed in year 2000 with the objective of improving the process of design information production, management and exchange (Coombes, et al., 2012).

The AEC (UK) committee was originally formed to generate a set of CAD standards and layer names, which are offered for free downloading, all copy rights granted (Woddy, Introduction to the AEC (UK) BIM Protocols, 2012a). In 2009, this committee released a *generic document referring to the techniques and concepts utilised in using BIM technology. It was intended to be applicable to all software platforms* (Woddy, AEC (UK) BIM Standard for Revit, 2012b).

This protocol has been adopted by numerous companies in the UK, Europe, the USA, Canada, Asia, Australia and Africa. In addition to the BIM protocol, this committee also made available a BIM Execution Plan designed to be used as a project document to which all disciplines can contribute, identifying file transfer protocols and promoting successful communication between teams and disciplines (Woddy, Introduction to the AEC (UK) BIM Protocols, 2012a).

The AEC (UK) BIM Protocol v2.0 builds on the guidelines and frameworks defined by the UK standards documents, including BS1192:2007, PAS1192-2 and BS8541-1 as well as existing, proven internal company procedures (Coombes, et al., 2012).

3.6. NATSPEC

NATSPEC was founded in 1975 as a not-for-profit organisation owned by the construction industry through professional associations and government property groups. It aims to be impartial and not involved in policy development or advocacy. The objective of this organisation is *to improve the construction quality and productivity of the built environment through leadership of information* (NATSPEC, 2013).

NATSPEC issued the National BIM Guide because it believes that this kind of technology *will provide improved methods of design, construction and communication for the Australian construction industry*. This is meant as a reference document to be adapted to the particular requirements of each project by using the Project BIM Brief developed either based on the BIM Guide or in consultation with the project team. This document can also be used as basis for clarification of services when preparing bids for projects in a nationally consistent manner in order to reduce confusion and re-work. These guidelines were developed based on the USA's VA BIM Guide[6] and adapted to the Australian context (NATSPEC, 2011).

[6] http://www.cfm.va.gov/til/bim/BIMGuide/

4. Findings Matrix

Table 2. First level findings matrix[7]. Legend: Y: it is covered/mentioned in the specific contract/guide, G: is covered/mentioned in the general conditions, N: Not found.

Contract / Topic	QTMR		NSW RMS		MRWA	CIOB CPC	AIA CA	AEC (UK)	NATSPEC
	ECI	D&C	ECI	D&C	D&C				
1. Service scopes	Y	Y	G	G	Y	Y	Y	Y	Y
2. Subcontracts	G	G	G	G	Y	Y	Y	N	Y
3. Changes	Y	Y	G	G /Y	Y	Y	Y	Y	Y
4. Outcome/ overall performance metrics	Y	Y	G	G	Y	Y	Y	Y	Y
5. Risk management/ distribution	Y	Y	Y	Y	Y	Y	Y	Y	Y
6. Collaboration/ coordination	Y	Y	G /Y	Y	Y	Y	Y	Y	Y
7. Selection process and criteria	Y	Y	N	G	Y	N	N	N	Y
8. Technology protocol	N	N	N	N	N	Y	Y	Y	Y
9. Information management	Y	Y	Y	Y	Y	Y	Y	Y	Y
10. Information hand-over/As-built doc.	Y	Y	Y	Y	Y	Y	Y	Y	Y
11. Information security/ confidentiality	N	N	N	Y	Y	Y	Y	Y	Y
12. Contract Model	Y	Y	Y	Y	Y	Y	Y	N	Y
13. Compensation	Y	Y	Y	Y	Y	Y	Y	N	N
14. Risk/Insurance	Y	Y	G	Y	Y	Y	Y	N	N

[7] It is possible that some of these topics are mentioned in separate documents which are not part of the information package provided by the road agencies for each type of contract.

5. Discussion

The following section will address whether the studied contracts address the questions raised by the 3xPT Strategy Group Report under each topic (shown in the introduction), determine gaps and how these could be bridged.

5.1. Service Scopes

The current practice across the three Australian agencies studied is to use the Scope of Works and Technical Criteria (SWTC) as the main document to define the service scopes. QTMR's and NSW RMS' approach includes the use of a project brief which NSW RMS explains should contain the answers to some of the questions outlined by the 3xPT Strategy Group such as: What does each company do and deliver on the project? (specific work contemplated in the contract), and what are the performance criteria for each service/company? (requirements to achieve effective and efficient use and operation of the works and for achieving fit for purpose status) (NSW RMS, 2013c). However, because these are project specific documents it is not possible to assess to which degree they answer all the questions.

In contrast, the CIOB uses the Working Schedule and Planning Method Statement to define the activities and their duration, links between activities for submittal, periods of consideration, correction and reconsideration; for each design stage and level of development. It also defines regular meetings to track performance to at least once per month and uses this document to include the resources planned to be used, productivity expected to be achieved, quantity of work planned to be completed, calculated duration and the planned value (CIOB, 2013a). This document would, if carried out in accordance to the CIOB contract, answer all the questions raised by 3xPT Strategy Group.

AIA proposes the use of the Building Information Modelling and Digital Data Exhibit (BIM&DDE) E203–2013 to layout the relations between the use of BIM and Digital Data to the original agreement. This would allow having a 'general conditions of contract' document and using a BIM&DDE type document to redefine the parties' scopes of services, scopes of work, and related compensation when using BIM/VDC.

The AEC (UK) uses the Project BIM Execution Plan to answer the service scope questions such as key project tasks, outputs and model configuration, including formats to be used, goals and uses, workflow required to deliver outcomes, standards to be used, software platforms, etc. (Coombes, et al., 2012). NATSPEC suggest the use of a similar document: the BIM Management Plan (BMP), but defines it to a lesser level of detail than the AEC (UK).

5.1.1. Levels of Development and Model Elements

In complex projects using BIM the use of clearly defined Levels of Development (LOD) for each Model Element in the BIM Management Plan/Execution Plan facilitates the delineation of the service scopes and consistency across the different project delivery phases.

A BIM is composed by a number of elements which might be developed by many different organisations or individuals. The AIA argues that breaking down the model into its component parts or "elements" simplifies the task of assigning responsibilities for managing and coordinating the BIM development to appropriate project participants, and assigning the LODs (AIA, 2013f). Working within the framework of defined LODs:

> *Allows the project participants to understand the progression of a Model Element from conceptual idea to precise definition and description. Each LOD allows the Project Participants to describe the content requirements associated with the LOD. The LOD framework allows the Project Participants to identify 'Authorized Uses' for the Model content at each LOD* (AIA, 2013f, pp. 11, 47).

The importance of defining the "Authorised Uses" is also a point that is made by the CIOB (CIOB, 2013b).

In the context of current procurement practices in Australia, NSW RMS could for example either substitute "[insert]% of the total value of the discrete design element" for the LOD of discrete model elements in their payment schedule clauses of the D&C Deed Schedule (NSW RMS, 2013a, p. 10)[8] or use a document similar to the AIA BIM&DDE to redefine this section of the standard contract.

There are different ways of defining the LODs, for example, AEC (UK) recommends the use of a "Model Development Methodology" during the early stages to enable rapid model development with low hardware requirements. These are classified as follows:

- G0 – *Schematic, symbolic place holder, particularly relevant to electrical symbols which may never exist as a 3D object*
- G1 – *Concept, simple place holder, minimum level of detail, superficial representation*
- G2 – *Defined, contains relevant metadata and technical information, sufficiently modelled to identify type and component materials, at least a 2D level of detail suitable for the "preferred" scale, sufficient for most projects*
- G3 – *Rendered, as G2 but in 3D representation* (Coombes, et al., 2012).

In contrast, as highlighted by NATSPEC, AIA's Document E202 – 2008 Building Information Modeling Protocol Exhibit defines LODs as describing *the level of completeness to which a Model Element is developed.* The AIA then uses five LODs where *each subsequent level builds on the previous level and includes all the characteristics of the previous levels* (NATSPEC, 2011). These levels are:

- LOD100 – Model elements might be graphically represented as symbols and may be analysed based on volume, area and orientation by application of generalised performance criteria
- LOD200 – Model elements are graphically represented within the model as a generic system, object or assembly, with appropriate quantities, size, location, and orientation. This level may include non-graphical information and may be used to analyse the performance of selected systems. It also may be used to show ordered, time-scaled appearance of major elements and systems
- LOD300 – Model elements are graphically represented within the model as a specific system, object or assembly and can be used to develop cost estimates suitable for procurement based on specific data provided
- LOD400 – Model elements includes details of fabrication, assembly and installation information. Costs are based on actual cost at buyout. It can be used for scheduling including construction means and methods
- LOD500 – Model elements are a field verified representation (AIA, 2013c).

The CIOB on the other hand, describes the lowest level of maturity as LOD0 and the highest as LOD3, where LOD2 is a coordinated 3D model comprising separate models with data attached (CIOB, 2013b).

[8] This clause establishes the constraints for payment schedule in terms of percentage of the total value of design elements of the contractor's work at different design development stages.

This is similar to NSW RMS' levels of development of the design documentation which are defined in terms of: developed concept design, preliminary detailed design, substantial detailed design and final design documentation states (NSW RMS, 2013b).

5.2. Subcontracts

The general conditions of contract across the three states are similar in relation to subcontractors, in that it is the contractor's responsibility to make sure the subcontractors are well coordinated, deliver all requirements and follow the same code of conduct as those specified in the contract agreement. However, the level of involvement of subcontractors in the development of the construction strategy differs between the two contract types studied.

For example, stage 2 of QTMR's ECI contract requires that the participants decide who will form part of construction team, which might include subcontractors if deemed necessary. This team is coordinated by the contractor and is in charge of developing the construction strategy (QTMR, 2009f).

NSW RMS also includes in their General Conditions that, independently of the contract type, the parties must decide jointly who will participate in the evaluation and performance monitoring meetings, which may include subcontractors, suppliers, consultants, and if appropriate, representatives of government authorities (NSW RMS, 2013c).

Therefore, QTMR's ECI and NSW RMS' General Conditions have embedded procurement process that should lead project managers to answer the first three questions raised by 3xPT Strategy Group.

Interestingly, the last question might be answered by MRWA's Conditions of Contract for Construct Only projects. This requires a trade coordination meeting with subcontractors where a coordinated model is used to review and optimise scheduling and field installation, so subcontractors actively engage in the coordination process and make schedule commitments (MRWA, 2013). In their D&C, subcontractors might be represented in the Project Review Group which meets monthly (MRWA, 2014).

The CIOB addresses these questions by including subcontractor's in the list of players listed in the definition of design contribution and the works, ensuring that they are included in the table shown in section 8 and other sections describing tasks and responsibilities (CIOB, 2013b). This might be a good choice if standard terms are being redefined in additional attachments, which are only used in complex and/or BIM-enabled projects.

AIA's documents also focus more on the responsibilities of the subcontractors and how to ensure that all participants follow the same standards. However, as to answering the 3xPT questions it only goes as far as highlighting the importance of "key supporting participants" and all stakeholders, which include subcontractors and consultants (AIA, 2007), without going into detail as to when and how these participants are to be selected and integrated into the strategy.

Similarly, NATSPEC focuses on responsibilities and technical requirements of subcontractors.

5.3. Changes

The General Conditions of QTMR, NSW RMS and MRWA, and the CIOB contract all handle changes through variations, which have to be accompanied by assessment of viability and impacts to project outcomes and cost.

However, under the QTMR's ECI contractor, designer and client must consider, agree and confirm changes together during stage 1 design workshops. The price of changes affecting the RAP is negotiated progressively with the client (QTMR, 2009e). Any changes needed during stage 2 are discussed during the monthly construction team design reviews (QTMR, 2009f).

NSW RMS adds that if the changes are likely *to offer significant benefits (including long-term or repeated benefits) to the client… both parties must agree to the financial benefits each will receive*, unless the contract information document already states the proportion of any savings to be shared (usually 50%) (NSW RMS, 2013c).

AIA's BIM&DDE establishes that the process by which project participants are to identify, coordinate and resolve changes to the model is to be included in the modelling protocols (AIA, 2013b) and the AIA GIC-DPD strongly suggests that the project participants should develop a process to document the receipt of, and agreement to, changes to the protocols by each participant (AIA, 2013f). Changes to the design are negotiated with the client (if they fall outside of the agreed scope of works) and recorded in the project documents (AIA, 2007).

The AEC (UK) addresses changes from a more technical point of view, stressing that any changes should be carried out as 3D modifications and that participants not involved with the design of the model should only have viewing access to non-editable versions (Coombes, et al., 2012).

NATSPEC uses the BMP to define the strategy for updating and coordinating changes during construction into the final BIM model deliverable files (NATSPEC, 2011).

Clauses such as that of NSW RMS and QTMR's ECI to negotiate and share financial benefits arising from changes to the design can motivate the contractor to improve its service to the client by innovation. The benefits of this type of clauses are maximised in contract models where the contractor's involvement starts during the earlier stages of the project (see Figure 4). This could be added to the recommendation by NATSPEC so the BMP includes a benefit sharing clause which is applicable to complex project using such document. It should also be highlighted that ECI type contracts tend to motivate participants to define changes at earlier stages of the project therefore minimising changes at later stages of construction when they are most expensive in cost and time (Sanchez, Lehtiranta, & Hampson, 2014).

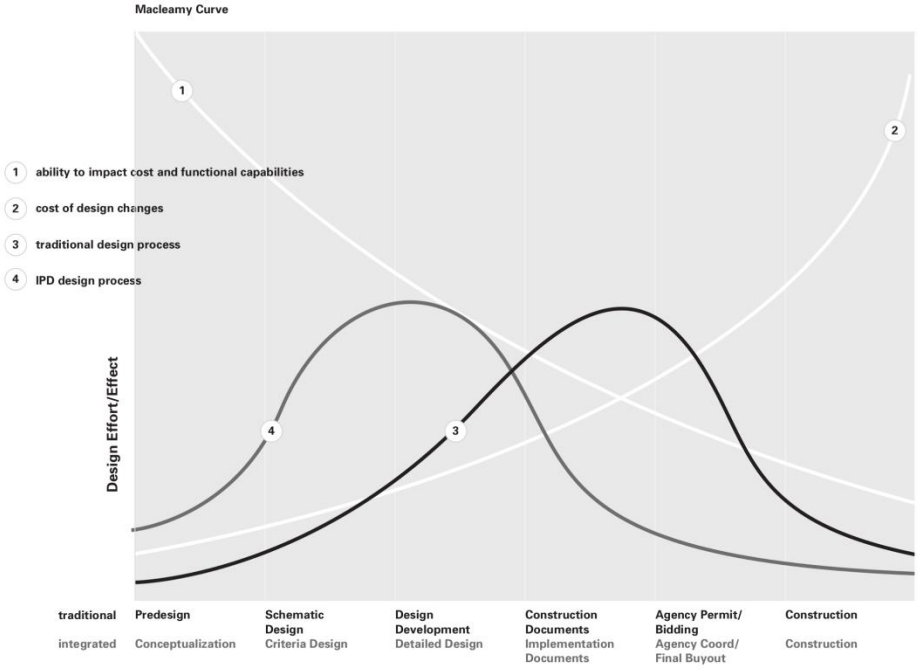


Figure 4. ***"MacLeamy Curve" illustrates the concept of making design decisions earlier in the project when opportunity to influence positive outcomes is maximized and the cost of changes minimized, especially as regards the designer and design consultant roles*** **(AIA, 2007).**

5.4. Outcome/Overall Performance Metrics

QTMR's stresses the importance of this point by highlighting that if the brief inadequately defines clear performance, technical and quality criteria, there is the risk of project failure (QTMR, 2011; QTMR, 2009b). Therefore, objectives for durability, design life, operational criteria, standards of finish and aesthetics, community and environmental standards should be defined (QTMR, 2009b). In the case of the standard D&C, the brief details the minimum design and construction standards to be achieved and deliverables through the use of "hold points" (QTMR, 2011). In stage 1 of their ECI, the contractor prepares a detailed planning and preliminary design report which includes performance metrics and outcomes (QTMR, 2009e).

Similarly, NSW RMS makes use of the contract program prepared by the contractor to address this set of questions (NSW RMS, 2013c). Both QTMR's ECI and NSW RMS General Conditions also require meetings to evaluate the project performance by the individual participants, RMS also offering a template form for this evaluation which can be adapted to contract-specific performance metrics.

MRWA requests that their contractors perform in accordance with probity requirements, terms of contract and current best practices. The task of reviewing the progress of the project in relation to the program and the performance of the contractor is assigned to the Project Review Group. This group is formed by a MRWA representative and contractor key personnel such as: project manager; design manager; construction managers; safety and site environmental mangers; quality manager; communication and stakeholder engagement manager; site traffic manager; subcontractor representative and any other personnel that MRWA might deem required (MRWA, 2014).

The CIOB uses the Design Execution Plan to define performance specifications including duration and milestones for each LOD. This document is reviewed and approved by the Project Time Manager on regular basis (CIOB, 2013b).

If AIA's recommendations are followed, then 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. Depending on the project goals, some of these metrics might also be associated to quality of construction or other less easily linked to clear key performance indicators, in which case it is recommended to use weighted indexes or independent evaluators. Additionally, it is suggested that financial bonus clauses, such as NSW RMS' innovation clause, tied to success criteria based on these metrics can further motivate participants. In all cases, it is important to not only define the key performance indicator but also the success criteria (AIA, 2007).

The use of BIM can be very beneficial for this process by providing a common access database where these KPIs can be recorded and reviewed by all participants, potentially motivating them to increase their scores. The use of BIM would require the use of new metrics, such as those recommended by AEC (UK) to be addressed in the Project BIM Execution Plan which provides a list of areas where BIM-specific metrics are needed and detailed recommendation on output compilations (Coombes, et al., 2012). Additionally, NATSPEC's recommendation is also important for organisations aiming to integrate their data management throughout the supply chain, so the BIM outcomes (as-built) and metrics should be aligned with the requirements of facility and asset managers (NATSPEC, 2011), which would answer the last question under this topic (what do the users expect from the facility?).

5.5. Risk Management/Distribution

Risk is clearly defined by QTMR, NSW RMS and MRWA in their general conditions to be mostly borne by the contractor. However, the risk distribution is different for ECI contracts where it is shared among participants. QTMR additionally stipulates that risk management workshops are to be used during stage 1 to develop a strategy to manage and minimise risk, among other. These workshops can be facilitated by a "risk facilitator" and involve risk modelling. The identified risks are used to estimate the RAP by an independent estimator and might be used to define the stage 2 offer (QTMR, 2009e; QTMR, 2009c).

The idea that all participants that form part of the tenderer entity in the ECI are *causally responsible for the acts and omissions (including breaches of this document) of the other as if those acts or omissions were its own* (NSW RMS, 2013d) is in line with the AIA recommendation to share the risk of non-performance among all participants in order to promote collaboration across traditional roles and responsibilities (AIA, 2007). Furthermore, the contractually defined risk will define whether the BIMs from different phases of the project delivery can be integrated (NATSPEC, 2011).

In cases where the participants are not comfortable with equally sharing the risk, the apportioning can be negotiated on a project-by-project basis (AIA, 2007), this can be based on the technical disciplines involved so each is responsible for the data they have created (NATSPEC, 2011).

Nevertheless, NATSPEC recognises that the integration and apportioning of risk depends on the acquisition strategy (NATSPEC, 2011). This aspect is more obvious in the CIOB contract which allows different risk distribution depending on the delivery model chosen. However, for most cases provided, the risk is solely borne by one of the participants. In this sense, the Australian ECI contract approach is the closest to IPD.

The AIA further provides guidance as to how to manage the risk when using BIM by having clearly defined authors who are responsible for evaluating, mitigating and resolving any potential conflicts found by any other user (AIA, 2013c), while encouraging a no-blame culture. Other practical recommendations found to manage and reduce risk are: (i) to test the exchange workflows prior to commencing the project models (AEC (UK), 2012b); (ii) to issue model files in conjunction with verified 2D document submissions; and (iii) to encourage all users to save their models regularly (at least once per hour) (Coombes, et al., 2012).

5.6. Collaboration/Coordination

All documents studied provide extensive answers to these questions with details of meetings frequencies and objectives. QTMR's approach is particularly interesting because they have defined a project value over which a more integrated collaboration is required (from AUD10 million) or optional (from AUD3 million) through "extended partnering" (QTMR, 2009b). Independently of the value, their ECIs also include the development of a "relationship management plan" which includes core values, guiding principles, and relationship goals and objectives. This document is used for monthly assessments in the form of the "ECI Health Assessment Form" (QTMR, 2009c; QTMR, 2009e), and is similar to the "collaboration standard" recommended by NATSPEC (NATSPEC, 2011).

It is also mentioned that *monthly project management team meetings provide a forum for the client to work with the construction team to resolve issues as they arise* (QTMR, 2009f). NSW RMS makes a similar argument for D&C project design group meetings (comprised by at least: client representative, contractor's design manager, contractor representative, and the project verifier) (NSW RMS, 2013b), and for ECI workshops (NSW RMS, 2013d). These type of meetings fall under the Level 1 described by the ACIF-APCC Project Team Integration Workbook (2014), where Level 2 includes all senior staff of the contractor, designer, and sub-contractors and Level 3 are on-site job captains, foremen and supervisors. Please refer to this workbook for more information on how to rate the level of team integration and collaboration that promotes the conditions for successful IPD outcomes.

In MRWA, the contractor must hold regular design meetings with the design team, consultants and Design Verifier to which the client representative can attend. Clause 23 of their D&C also states that MRWA intends to establish a partnering agreement with the contractor to encourage parties to work in an *open, cooperative and collaborative manner and in a spirit of mutual trust and respect* (MRWA, 2014).

In contrast, the AIA BIM&DDE assigns the coordination responsibilities to each model element author, regardless of who is responsible of providing the content (AIA, 2013b). The BIM-PF further establishes communication protocols, collaboration meeting schedule and co-location requirements (AIA, 2013c).

The CIOB uses the Working Schedule and Planning Method Statement to coordinate the data submissions. This document can also be part of the Design Execution Plan (CIOB, 2013a).

Key practical issues that should be identified and coordinated at early project stages are: (i) communication methodologies and technologies; and (ii) key parameters agreed upon regarding: BIM platform(s), administration and maintenance of BIM(s), source of "truth" for all data, interoperability criteria, data transfer protocols, level of development by phase, and development of tolerances (AIA, 2007). Another practical recommendation could be to use BIM authoring tools, data integration, and collaborative team workflow environments (NATSPEC, 2011).

AEC (UK)'s BIM Protocol also highlights the importance of including not only internal communication and file transfer but also that needed for external collaboration in the Collaboration Guidelines. This should allow maintaining the integrity of the electronic data and identifying clear ownership of the BIM elements/objects through the life of the project. To improve this, a "Skills Matrix" might be beneficial to assign responsibilities related to primary functions to different roles (e.g. strategic - creation of standards, training, implementation, etc; management - execution plan, model audit, model coordination and content creation; and production - modelling and drawings) (Coombes, et al., 2012).

Independently of the chosen approach, it is important for the project team to be involved in the setting of objectives, strategies and actions included in the project management plan (ACIF & APCC, 2014).

5.6.1. Coordinating Role in IPD/BIM-based Projects

A common topic found in IPD and BIM guidelines is the need for at least one coordinating role across the life of the project to verify submissions and guarantee that all parties are using the verified data. The AIA IPD guide for example proposes the Integrated Project Coordinator. This role is responsible for the overall facilitation, coordination, organisation and direction of the integrated team; team's compliance with owner's requirements; overall project schedule; completeness of necessary project information; coordinate assignment of responsibilities, actions and completion requirements; coordinate alternative options for presentation to the client; ensure compliance with project requirements; among other.

However, the need for this role is not new in Australia. The Queensland Division Task Force Engineers Australia pointed out in 2005 that the absence of an experienced client-appointed, overall Design Manager/Coordinator was one of the causes of project cost overrun (Queensland Division Task Force Engineers Australia, 2005).

Current forms of contract at QTMR, NSW RMS and MRWA also have provisions for the existence of a role that coordinates or verifies design outputs:

- QTMR's Design Review Manager is sometimes used to coordinate the submissions throughout the different stages. This role is carried out by the same person from tender preparation through to completion (QTMR, 2011)
- NSW RMS' Project Verifier certifies documentation to be used so that the *parties are entitled to and will rely on any certificate or other document signed or given by the project verifier under or pursuant to this deed or the project documents* (NSW RMS, 2013a).
- MRWA's Contractor Design Manager manages and coordinates all design documentation and construction documentation in accordance with the contract requirements. The Design Verifier certifies design documentation at 15%, 85% and 100% of completion and provides a final report to MRWA (MRWA, 2014).

The key difference might be that the Integrated Project Coordinator proposed by AIA also has responsibilities which have been traditionally carried out by the Project Manager such as: coordinate and track integrated team's performance; lead selection of integrated team members; coordination of overall project schedule; coordinate complete information for legal requirements of project as it relates to the client's procurement method; overall coordination and management of the Agency Review process; and coordinate team input and facilitating team buy-in for overall project schedule and budget (AIA, 2007).

The CIOB has divided these responsibilities between two roles:

- Project Time Manager: identified in the contract agreement to coordinate the submitted documents and the archive, unless the data is automatically maintained in a common data environment. This role also checks and evaluates the progress records, and can be appointed by the client or the contract administrator
- The Design Coordination Manager: identified in the contract agreement as being responsible for maintaining a database of submittals of any contractor's design contribution, and for the coordination and maintenance of the client's BIM. This role is appointed by the contractor if the works include the development of the BIM or by the client if the BIM is provided (CIOB, 2013a).

These roles gain even more relevance when using BIM. The AEC (UK) BIM protocol for example, stresses the importance of having three roles: BIM Manager (strategic); Coordinator (management); and Modeller (production). In small projects, all three roles could be carried out by a single individual. The management function is project and BIM-specific; the coordinator helps set-up the project, audit the model and coordinate with all collaborators (this role may manage several small projects); and the modeller is a technically skilled role and project-specific (Coombes, et al., 2012).

NATSPEC also outlines three roles:

- Design Team BIM Manager responsible for: development and compliance with the approved design BMP; coordinating software training and file management; assembling the information for the coordination meetings and facilitating its use; coordinating between disciplines and ensure they are operating properly; and ensuring that the design deliverables specified in the contract are provided in conformance with the formats specified, among other responsibilities
- Construction Team BIM Manager responsible for: the construction BIM model and any information developed during construction; coordinating software training and establishing software protocols; coordinating of teams; coordinating construction sequencing and scheduling activities that are integrated with the BIM; facilitating the use of the model by all trades; and coordinating the update of as-built conditions in the Final Model deliverable, among other responsibilities
- Technical Discipline/Trade Lead BIM Coordinators (can be as many as necessary) responsible for: coordinating technical discipline BIM development, standards, data requirements, etc., as required, with the Design Team BIM Manager; leading the technical discipline BIM team in its documentation and analysis efforts; coordinating internal and external BIM training as required; and coordinating trade items into the Design BIM (depending on acquisition plan) (NATSPEC, 2011).

The AIA documents place most of the model and digital data coordination and protocol development on the Architect. However, Architects have limited roles in civil engineering and transport infrastructure construction. Therefore, this responsibility allocation is not adequate to this sector and a case might be made for the creation of a new role that can be independent of the parties involve. Such a role could be the BIM and digital data or integrated project coordinator similar to NWS RMS's and MRWA's verifier.

Additionally, Trafikverket has recognised that internal BIM coordinators might be required in future to manage hand-offs from suppliers and between phases as well as managing knowledge transfer across projects and actors (Trafikverket, 2013). This role might be similar to AEC (UK)'s Coordinator (management). Currently, Traffikverket engages the role of the 3D Coordinator to ensure that the right information is delivered in a coordinated interoperable manner by the various technical disciplines (Johansson, 2012).

AIA explains that *assigning the responsibility to prepare written digital data protocols to a single Project Participant creates an advocate for the development of the protocols and is intended to ensure that the task is complete. For example, if an Owner's representative has established protocols for document management, or if a Construction Manager is responsible for managing project information, it may make more sense to have that Project Participant prepare the written protocols* (AIA, 2013f, p. 18).

These roles however do not necessarily have to be carried out by the same individual. For example section 3.5.3 of AIA's GIC-DPD allows some of these responsibilities to be assigned based on project milestones due to the fact that, throughout the project life-cycle, *there may be different individuals or entities better suited to manage the centralized digital data* (AIA, 2013f).

However, as highlighted by 3xPT Strategy Group having a single process and model coordinator can facilitate the use of BIM *to represent the key project information for several members of the IPD team and over several project phases* (3xPT Strategy Group, 2007).

Coombes, et al. (AEC (UK) BIM Protocol V2.0, 2012) also stress the vital strategic role of the BIM manager. *It is not simply a rebranded CAD Manager, nor does it replace the CAD Manager's role. It is about understanding what BIM can achieve: vision, engaging external stakeholders, collaborating partners and the internal teams. Somebody credible has to be responsible for the BIM strategy, the process change and the cultural impact. In-house or outsourced, successful models cannot be built without a strategic manager Business and project size will dictate the structure of the BIM team. The BIM Manager could perform all functions on smaller projects. No matter how large the project you only need one person responsible for the strategic function*.

5.7. Selection Process and Criteria

QTMR and NSW RMS use a combination of price and non-price selection criteria for tender assessment which differ depending on the road authority and the type of contract. QTMR's ECI for example has two mandatory criteria based on pre-qualification and financial positioning, and 3-5 non-price criteria which may include: relevant experience, track record, methodology, supply chain management, proposed approach, and resources (QTMR, 2009c). The ECI also makes use of interactive workshops to evaluate the team's commitment to the integrated team and relationship management principles (QTMR, 2009d).

NSW RMS' policy includes that the tender offering best value for money should meet the basic assessment criteria and ensure that the specified work is carried out at the specified quality, to the specified environmental and safety standards, within the specified time, for the lowest price and performed in the spirit of cooperative contracting (NSW RMS, 2011). However, larger and complex D&C projects where a detailed tender assessment is undertaken price should be scored with a weighting in the range of 80% - 90% (NSW RMS, 2011).

MRWA appoints a team to evaluate the proposal from 3-4 proponents chosen based on their Expressions of Interest and provide recommendations regarding the preferred proponent. This recommendation is then endorsed by the Executive and the Director Infrastructure Delivery and approved by the Commissioner of Main Roads and the Western Australian Minister of Transport (MRWA, 2014). However, there is not description of the criteria used for the evaluation of the tender.

Based on this assessment, only QTMR's ECI outlines a process that follows the AIA recommendation to include the team as part of the selection criteria. This is key to: (i) achieving the level of comfort

that project information exchanged will be used only for the purposes of the project; (ii) minimise the likelihood of disputes arising over whether the goals have been achieved; and (iii) avoid conflicts of interest related to price (AIA, 2007). Although, NSW RMS also mentions that the tenderers are to be assessed based on their ability to perform the works in the spirit of cooperative contracting, this definition is rather vague and might be difficult to rate by the Tender Assessment Committee.

If a BIM environment is to be used, it might also be of benefit to include the qualifications, experience, and previous success in BIM coordination of the proposed Design BIM Manager, the Design Team, Construction BIM Manager, contractor and major subcontractors, as part of the selection criteria (NATSPEC, 2011).

5.8. Technology Protocol

Both QTMR and NSW RMS seem to leave the selection of the tools to either the contractor or the procurement manager in charge. MRWA does not mention specific tools or software in their D&C contract.

The CIOB includes a BIM Protocol which is meant to be filled with detailed information about the tools and protocols to be used. If left empty, then AIA's Document E202-2008 BIM Information Modelling Protocol Exhibit or the latest edition is to be used. The software used for the working schedule is specified as an appendix and depending on the level of complexity and ability to handle a quantity of data; the software adapted for a BIM may also be capable of producing the time management data. The CIOB protocol also includes tables which are to be filled with the personal expertise needed for each individual task at each stage of development (CIOB, 2013a). Similarly Coombes, et al. (2012) suggest the creation of a "Skills Matrix" where responsibilities related to primary functions: strategic (creation of standards, training, implementation, etc); management (execution plan, model audit, model coordination and content creation); and production (modelling and drawings), are clearly assigned to different roles. Both approaches would answer the last question under this topic.

AIA's BIM&DDE assigns the architect with the responsibility to develop the protocol to be used for transmission, use, storage and archiving the data, and development and management of the BIM (AIA, 2013c). The development protocol must address:

(i) Identification of the model element author
(ii) Definition of the various LOD for model elements and associated authorised uses for each LOD
(iii) Identification of the required LOD of each model element for each milestone
(iv) Identification of the construction classification system to be used
(v) Processes for transmission and sharing
(vi) Processes by which participants will identify, coordinate and resolve changes to the model
(vii) Details regarding anticipated as-designed or as-constructed authorised uses for the model
(viii) Anticipated authorised uses following completion of the project
(ix) Other topics.

While the management protocol addresses:

(i) Model origin point, coordinated system, precision, file formats and units
(ii) Model file storage location(s)
(iii) Processes for transferring and access model files
(iv) Naming conventions

(v) Processes for aggregating model files from varying software platforms
(vi) Model access rights
(vii) Identification of design coordination and clash detection procedures
(viii) Model security requirements
(ix) Responsibilities of the model manager (architect unless noted otherwise) to:
    a. Collect incoming models (coordinate submission and exchange of models; create and maintain a log of models received; review model files for consistency; and maintain a record copy of each model file received
    b. Aggregate model files and make them available for authorised uses
    c. Maintain model archives and backups consistent with the archive requirements
    d. Manage model access rights
(x) Other.

In contrast, the AEC (UK) has a single BIM Protocol which includes more concise recommendations such as: modifications should be kept to a minimum unless the received data format prevents design processes, in which case the coordinator must provide approval for the modification of the incoming data; CAD data might need to be shifted to 0,0,0 before importing; details of the changes made during the "cleansing" of the data must be documented in the Project BIM Execution Plan; the ownership of this "cleansed" data is transferred from the originator to the "cleansing discipline" which is then stored with the Work in Progress (WIP) data unless deemed appropriate to be shared; and accuracy of approximately 1:50 for the 3D modelling. The protocol also provides recommendation about the spatial location and coordination systems, units and measures (Coombes, et al., 2012).

Additionally, NATSPEC recommends the use of open standards and that the BMP should also address methods for showing major equipment space clearance reservation for operations as well as for showing functionality and circulation paths for the delivery, supply, processing and storage of material; proposed BIM software to be used by each discipline; and strategy to import/export data (NATSPEC, 2011).

5.8.1. BIM Protocol as an Addendum

The AIA argues that the benefits gained from the use of digital data depend on the team, the delivery method, and the project itself, and therefore it is impractical to identify a specific time for the establishment of the protocols (AIA, 2013f, p. 17). However, it is paramount to have a document which carefully plans the way that BIM will be implemented and managed as early as possible in order to achieve technical excellence and a successful outcome to a project (Coombes, et al., 2012).

This document must involve explicit attention to management, display and quality of the design data as well as guidelines for authoring, sharing and authorised usage of the output data (Coombes, et al., 2012).

This could be done through a standard BIM Protocol, created based on these recommendations and adapted to the needs of each road agency, available to procurement managers who wish to use BIM to include as part of the contract documents as an addendum. In a less prescriptive approach a clause could be added to current contracts requiring the development of a BIM Management Plan (BMP) to describe in a detailed way *how the project will be executed, monitored and controlled with regard to BIM in order to satisfy the requirements recorded in the Project BIM Brief* (NATSPEC, 2011).

Allen, et al. (2014) highlight that a common approach should be used by the whole industry including the adoption of plain language and a single name for this document to avoid confusion (i.e. BMP).

An additional clause would have to be embedded in all subsequent agreements requiring all participants to include the developed protocols. Including clauses of confidentiality and authorship (of each model element) could also provide an environment where authors are more likely to provide full models even if they are not to participate in subsequent project phases.

Taskin, et al. (2014) also found that the protocol should be included as a contractually binding document. Otherwise there is the risk of the project team seeing it as a *guide* and not being able to hold the parties responsible for compliance. This is supported by the industry feedback to NATSPEC provided by the group Collaborate ANZ[9] (Allen, et al., 2014).

Finally, it would be practical to include a clause requiring that all parties include a copy of the latest version of the protocol in the model itself so all project participants can access it. *This requirement is easily accomplished with current software capabilities and ensures that any project participant that receives a model will also receive the model protocols governing the use of the model* (AIA, 2013f).

5.8.2. Technical Requirements

It is important to highlight that what might be standard practice for some, may require a considerable learning curve for others, most of all when the speed of technological advancement is considered. Therefore, when choosing the system to be implemented, considerations of cost and level of effort for new users might be needed at very early stages of the process (AIA, 2013f).

Additionally, the scale of the project might need to be considered. For example, in small projects digital data might only be used for communications via email and therefore the software requirements would be different to a larger more complex project. To adapt to the digital data needs of individual projects, sections of the protocol can be changed to include the use of non-digital formats for specific data (AIA, 2013f). This might even be considered for different stages of the project based on the end-of-project needs, namely, as long as it does not affect the project outputs' interoperability with monitoring and asset management software.

Other related issues that need to be agreed upon are for example: the intended storage/archive life of the files and the cost of maintaining such archives, how long will each participant have access to them, and how the archive can be used (AIA, 2013f, p. 30). This also relates to the acquisition strategy and who owns the model.

NATSPEC (2011) also offers a series of technical recommendations related to the selection of the software, equipment coding, metadata, points of reference, modelling geographical location, and additional modelling standards.

5.9. Information Management

QTMR approaches this issue in their ECI via a "Pre-Start Conference" during stage 2 (QTMR, 2009f) and to a lesser degree in their D&C by recommending a stage verification process to be implemented (QTMR, 2011), similar to NSW RMS' "hold points" (NSW RMS, 2013b).

[9] Collaborate is a group formed by industry practitioners who *wish to present a holistic and unified representation of the AEC industry without attachment to any particular discipline or professional body* - http://collaborate-anz.com/main/?page_id=117

NSW RMS and MRWA specify the form in which the design documentation in D&C projects is to be delivered at the different defined stages:

- 4 -2 sets of all documents to the different relevant parties and a written report. The design must also be delivered in digital form as per the Scope of Works and Technical Criteria (NSW RMS, 2013b)
- 3 copies of draft design documentation relating to each discrete project design element which may be reviewed and commented upon (MRWA, 2014).

Additionally, MRWA requires the contractor to provide five copies of draft reports to the Project Review Group prior to each monthly meeting. MRWA also requires the contractor to keep one copy of all records in Perth for five years from expiry of the last defect correction period (MRWA, 2014).

However, the answers are not provided to questions such as: How is information shared? How is information updated? And what is the role of digital models (BIM)?

The CIOB requires a File Transfer Protocol (for uploading, downloading, managing access to, security of and transferring digital files by electronic means) and recommends the use of a Common Data Environment (CIOB, 2013a). Additionally, the table shown in section 8 contains all the relevant information for each level of development in terms of the design stage (including preparation for tender), geometry, content, analysis, cost control, time control, licensing and approvals, construction and other uses (CIOB, 2013a).

Ideally, all correspondence and other information flow should be managed by a document management system (DMS) and all data and documentation should be made available transparently, in native format to the contract administrator and listed persons (CIOB, 2013a).

AIA's "authorised uses", LODs and Project Digital Data Protocol Form (AIA, 2013e) answer all the questions under this topic by addressing issues such as: procedures and requirements for storing digital data during the project and archiving; and data formats, transmission methods and authorised uses from project agreements and modifications to close-out documents.

AEC (UK) also provides extensive details about how to address this questions by: (i) sub-dividing the work by disciplines; (ii) using levels of development classification; (iii) using a Common Data Environment which clearly classifies the data into WIP, shared, published and archived; (iv) having a BIM coordinator who verifies the minimum quality of compliance; and (v) using the BMP to describe the file sharing protocol (Coombes, et al., 2012). For large complex projects they also recommend dividing the model into "zones" or "packages of work"[10] and recording the file structure in a model matrix (AEC (UK), 2012a).

Additionally to the BIM protocol, NATSPEC requires copies of all approved submittals and other documents normally provided in traditional paper-based formats to be provided in PDF format. External documentation should also be made available in PDF format, either by conversion from the original format or scanning of the physical copies (NATSPEC, 2011).

5.9.1. Common Data Environment – Centralised Source of Truth

The responsibility for data integrity, including backups, periodic and milestone archiving, and logs of interaction, is critical to maintaining the value and integrity of the data within the model (AIA, 2013f).

[10] The AEC (UK) BIM Protocol, pages 21-23 offer general principles for the segregation of data in large/complex projects.

A Common Data Environment is a *web-based server that enables multiple users to collaborate in managing digital information in accordance with an agreed protocol* (CIOB, 2013b) and is recommended by the CIOB, AEC (UK) and AIA (AIA, 2013f; CIOB, 2013a; Coombes, et al., 2012).

The complexity of the systems can vary wildly from simple databases that allow users to view, use and modify digital data to document management products with document tracking, version control and other features (AIA, 2013f).

The use of centralised document management systems as the only source of truth is not only becoming more common among projects (AIA, 2013f) but also can avoid duplication of data which often results from planning authorities insisting on using traditional drawings (Sherman, 2013).

If such system is to be used, AIA also recommends that parties document *what the system is intended to achieve and how the system will impact the role of the Project Participants* (AIA, 2013f). This, with the help of the BIM Coordinator, might motivate participants to accept the new system.

5.10. Information Hand-over/As-built Documentation

QTMR, NSW RMS and MRWA answer the first two questions under this topic. NSW RMS and MRWA request both digital and physical copies (3-5) of the design documentation and drawings which are described to different levels of detail depending on the agency and the type of contract. QTMR requires physical copies of the as-built drawings, specifications, reports and "any relevant data" to be handed over for QTMR's Road Management Information System (ARMIS) (QTMR, 2011). The specific format of the digital copies is described by NSW RMS as enabling interrogation, manipulation, and re-calculation by RMS representatives, the project verifier, and where relevant, the proof engineer (NSW RMS, 2013b).

NSW RMS and MRWA address the question about quality control by requiring all drawings and design documentation to be verified by the project verifier (NSW RMS, 2013b; MRWA, 2014). NSW RMS also requires the verification to be done by the contractor and, when relevant, the subcontractor (NSW RMS, 2013b). QTMR's assigns the responsibility of certifying that the works have been carried out in accordance with the contract to the designers (QTMR, 2009e; QTMR, 2011).

The three agencies also require the intellectual rights ownership over the design documentation to be transferred to them.

The CIOB uses the Working Schedule and Planning Method Statement to control the post-contract design contributions and data dates (submission dates). There is no certification or verification specifically required and all the data is automatically licensed to the client at the moment it is published in the common data environment where it is accessible in native format (CIOB, 2013a).

The AIA uses the BIM&DDE to establish services associated with the post-construction model and the responsible participants (AIA, 2013b). However, it does not specify formats used for hand-over or quality control processes other than those established for general information management (see sections 8.3.8 and 8.3.9).

AEC (UK) does not specify a format but it requires BIM data to be prepared, checked and exchanged taking into account the requirements of any recipient software application (e.g. link to analysis packages or interface with GIS) and 2D outputs must be reasonably complying with the project CAD standards, and allow easy manipulation of the data held within the file (e.g. layering). Quality control of deliverables is left to the Team BIM Coordinators (Coombes, et al., 2012).

NATSPEC recommends that only final drawings are submitted to the client, so non-required data for asset management which was created throughout the project is "cleaned" out of the final data package. The model files should be delivered in native and IFC formats, the as-built drawings in PDF format with fully bookmarked pages and design intent model in PDF and DWG format, all in a CD/DVD (NATSPEC, 2011).

NSW RMS presents the most complete answer to the questions under this topic and the engagement of a project verifier should guarantee the quality of the as-built documentation delivered. However, if BIM is to be used, the CIOB or AEC (UK) approaches might be more practical if it is possible to have a common data environment. Finally, NATSPEC recommendations regarding "cleaning" the data so that only relevant asset management information is required would significantly reduce the storage needs and facilitate the accessibility of the relevant information.

5.11. Information Security/Confidentiality

QTMR does not address this topic, NSW RMS and MRWA classify all information relating to the contractor's work and any discussions related to the D&C deed confidential (NSW RMS, 2013b; MRWA, 2014). However, none of the three agencies provides information in the documents reviewed regarding roles involved in managing information security or how it might be reconciled with collaboration.

The CIOB assigns these responsibilities to the data security manager. The confidentiality clause expires three years after the termination date of substantial completion date, or if the data is no longer consider sensitive (CIOB, 2013a).

AIA confidential information is anything which is identified as such, and is only to be used for the purposes of the project at hand (AIA, 2013b). There is no role specifically dedicated to data security. However, they do recognise that the sharing of files is often a concern for professionals *due to the fear of losing control over, ownership of, and/or copyright in the files shared,* and recommend that an effort is made so all parties involved understand and agree to limits of use (through for example, authorised uses) so to encourage and protect the ownership of the data which often gains value with file sharing and collaboration (AIA, 2013f).

AEC (UK) strongly recommends that all BIM project data resides on network servers subject to regular back-ups and that staff access to BIM project data held on the network servers is done only through controlled access permissions (Coombes, et al., 2012). NATSPEC on the other hand recommends the development of a data security protocol and setting adequate user rights to prevent data loss or damage during file exchange, maintenance, and archiving (NATSPEC, 2011).

Finally, it is recommended that any indemnification language included in the contract documents is reviewed closely with legal and insurance counsel to avoid uninsurable obligations (AIA, 2013f).

5.12. Contract Model

As mentioned in earlier sections the contract model is particularly relevant to IPD and the use of more collaborative technologies such as BIM because of the manyfold impacts it has over methods of collaboration, project phases integration, involvement and responsibilities of different parties and the acquisition strategy. Contracts such as the CIOB Complex Projects Contract have been designed to accommodate almost any kind of contract model using traditional drawings or BIM. This section will discuss the suitability of some of the models for the use of IPD and BIM/VDC. Nevertheless, the

topics covered in this report should be addressed regardless of the contract model if BIM and/or IPD principles are to be implemented.

5.12.1. IPD, BIM and Traditional D&Cs

As explained by QTMR the client *has significantly less control over the design than it would under traditional delivery approaches*. Therefore, D&Cs must be significantly more prescriptive than other contract models in that the brief has to detail all the requirements clearly. This is *not an easy task, requiring significantly greater effort to obtain the benefits of D&C than in developing a design only Brief* and if the project is delivered in packages, the client might not *be able to fully appreciate certain design implications or ramifications on other related packages*. This risk is then magnified if there is a lack of coordination of the design development process by the contractor (QTMR, 2011).

This arm-length approach might lead to under-designing, poorly defined performance and quality requirements, lack of monitoring (QTMR, 2011) and coordination, and lower innovation rates (AIA, 2007). Additionally, even though it is possible to "fast-track" a D&C project, the approval processes can reduce the actual gains in terms of shorter project timeframes which in some cases have required up to 90% of design completion for award. Finally, the client also needs to develop the preliminary design to a significant level before engaging the contractor in order to progress the business case for land acquisition to secure the land corridor (QTMR, 2011). This can lead to potentially ignoring constructability issues that might have been prevented if an experienced contractor was involved in the design development discussions and creating barriers to integration of the models throughout the project life-cycle.

As highlighted by NATSPEC, *the success of a BIM enabled project delivery process is highly dependent upon the level at which the entire Design/Construction Team can communicate and work collaboratively for the duration of the project* (NATSPEC, 2011). However, the fact that the client has minimal involvement in the project development represents the largest barrier to implementing IPD principles (AIA, 2007).

Thus, as explained by Austroads' procurement guide, there is a growing trend towards adapting traditional contract models such as D&Cs to use more interactive and collaborative procurement processes. This enables closer communication between the tenderer and the client regarding the design documentation and the proposed approach to the brief (Casey & Bamford, 2013). For example, ECIs, also known as a negotiated D&C (QTMR, 2009a) have been identified as high value procurement models based on interactive tendering processes and are often used by Australian road authorities. The idea uses a *series of structured interviews and/or workshops held through the tender period to clarify the contract scope and documents and assess the performance of tenderers* (Casey & Bamford, 2013). Early Tender Involvement models have also been used by different road agencies across Australia for similar reasons, bringing the contractor at an even earlier stage into the project life-cycle.

These approaches aim at:

- *minimising misunderstandings arising from the project owner's documentation and project requirements*
- *improving the documentation (where necessary) prior to finalising the contract documents*
- *fostering a more open, transparent and collaborative project culture*
- *improving time and cost outcomes, including through the minimisation of contingency amounts in the tender price to cover unknown factors and risk* (Casey & Bamford, 2013).

Although ECIs and ETIs are more closely related to the IPD principles (going as far as making the participants' disposition to integration one of the selection criteria) (QTMR, 2009d), D&C contracts can be made more "IPD-friendly". For example by: increasing client's involvement (and reflecting this on the project agreement); changing the compensation model to link financial benefits to project goals that can promote greater collaboration; and using open book accounting for project cost to foster client's collaboration throughout the life-cycle of the project (AIA, 2007). Additionally, contractually defined risk should allow the integration of the BIM models (NATSPEC, 2011).

5.12.2. Performance Based Contracts and Non-traditional Models

The standard D&C procurement process starts at the end of the plan development stage on the basis of the request for proposal. As highlighted earlier, this is mostly after the conceptual design has been completed by the client and the main decisions have been made. The contractor would then be responsible for making the final design and for the realisation, and separately the maintenance of the infrastructure (Leendertse, Lenferink, & Arts, 2012).

Leendertse, Lenferink, & Arts (2012) argue that it is possible to start the procurement before the end of the plan development. Thus paralleling procurement and planning activities. This approach provides the opportunity to develop creative solutions and gain insight into the effects of proposed solutions during procurement, which can be used in parallel planning and decision making. The results can be: time gains, better risk and project control or creativity and early insight in execution impact.

As with ECIs and ETIs, involving the contractor earlier in the plan development stage (pre-tender phase) could potently lead to added value through more knowledge, expertise, creativity and commitment (Leendertse, Lenferink, & Arts, 2012).

Leendertse, Arts, & de Ridder (2012) argue that, to succeed in creating "network value" and stimulating resource based competition, road authorities can use the following approaches: performance based contracts, design freedom based on functional specifications and economically most advantage tender, quality assurance partly based on past-performance (pre-selection) and contract monitoring.

The Netherlands successfully implemented the following two approaches, with strong financial outcome-based incentives, reduced scope discussions during execution, and low transaction cost (Leendertse, Lenferink, & Arts, 2012).

- Market consultation: pre-selected contractors are consulted about the feasibility of a proposed scope, technical solution or process worked out by the government (no obligations attached)
- Early design contest: the objective is to "tempt" contractors to generate creative solutions by providing a price incentive. In this case, the Request for Proposal (RFP) defines the problem, requirements and conditions. The best timing for this approach is relatively early in the planning process (Leendertse, Lenferink, & Arts, 2012) and could be used as an alternative to traditional D&Cs in order to involve contractors at an earlier stage of the process.

In ECIs, the designer chosen in stage 0 assists in developing the design information for tender documents including site plans and concept drawings, permits/approval requirements, planning layout drawings and survey drawings and models. However, QTMR highlights that *one of the aims of the ECI contract is to keep the design flexible so that there is opportunity for development and*

influence once the contractor has been selected (QTMR, 2009d). Therefore, the necessary approvals and land acquisition are often obtained by the client during stage 1, after the Detailed Planning and Preliminary Design Report has been completed by the contractor (QTMR, 2009e).

Nijsten, Arts, and Sandee (2010) carried out several case studies for infrastructure construction projects where the contractors were involved in a collaborative relation with the client during the planning process. It was concluded that the alignment of project scope and objectives between parties is fundamental for the success of the project and that early market involvement might provide tools for involving the public and resolving sustainability issues. In addition, there were incentives for meeting extra needs and the model helped the road agency to meet their time, budget and quality requirements.

5.13. Compensation

ECIs compensate their contractors for their services for stage 1 based on reimbursement of time and rates submitted during tender (QTMR, 2009d). The stage 2 offer is negotiated with the parties involved based on the RAP and other considerations. The tenderer not chosen for stage 2 is compensated based on the original agreement for their involvement in stage 1 (QTMR, 2009c; QTMR, 2009e; NSW RMS, 2013d). In contrast, D&Cs use milestone payments based on design and construction elements being delivered (NSW RMS, 2013a; MRWA, 2014). Additionally, QTMR procurement managers have the option of offsetting the tender preparation cost through financial contributions to the tenderers, most of all in those cases where the most attractive solution is a combination of proposals, in which case an offer contribution amount may also be used to compensate the tenderers (QTMR, 2011). MRWA also states that any savings arising from changes proposed by the contractor are shared equally between the two parties (MRWA, 2014).

Nevertheless, beyond traditional compensation schemes, linking financial benefits with project goals can increase collaboration and integration across the project. In this respect QTMR's ECI design savings bonus (QTMR, 2009c; QTMR, 2009e) and NSW RMS' innovation (savings sharing) clause (NSW RMS, 2013c) are directly in line with IPD principles and recommendations made by AIA (Integrated Project Delivery: A Guide, 2007). QTMR's ECI's open books approach for determining the RAP (QTMR, 2009e) is also consistent with IPD principles.

The CIOB does not focus on the payment method, although it does include any suggestion by the contractors (as to how the works may be more cost effective) as "design contributions" and is therefore added to the value of the contract (CIOB, 2013a).

5.14. Risk/Insurance

QTMR, NSW RMS and MRWA provide a type of Principal Arrange Insurance (PAI) which covers the main parties involved in the contract. In the case of MRWA, this is done in the form of three policies: Contract Works Material Damage Insurance Policy ("CWMDI Policy"), Contract Works Liability Insurance Policy ("CWLI Policy") and Workers' Compensation Insurance Policy ("WCI Policy") (MRWA, 2014).

Additionally, contractors and designers are required to acquire other types of insurance:

- QTMR ECI stage 1: Insurance of the Works, Professional Indemnity Insurance, Public Liability Insurance and Employer's Liability Insurance (QTMR, 2009e)
- QTMR D&C: Professional Indemnity Insurance, Worker's Compensation Insurance and Public Liability Insurance (QTMR, 2011)

- NSW RMS General Conditions: Workers' Compensation, Professional Indemnity Insurance (if required by contract) and Motor Vehicle/Plant Insurance or Third Party Property Damage Insurance (NSW RMS, 2013c)
- MRWA D&C: Contractor's Plant & Equipment; Motor Vehicle Insurance; Professional Indemnity Insurance and Goods in Transit (MRWA, 2014).

The project verifier involved in NSW RMS' D&C also is required to acquire a Professional Indemnity Insurance for AUD10 million covering the appointment and 6 years following completion (NSW RMS, 2013a). Contractors must also make sure that subcontractors are insured.

However, QTMR is responsible for effecting and maintaining the required insurance policies for the works through stage 2 (QTMR, 2009f) and there are additional alternatives to PAI available to procurement managers (QTMR, 2009b).

The CIOB leaves the insurance arrangements to be decided on a contract-by-contract basis although it does stress that all parties must be insured and the contractor is liable for the development of the works (CIOB, 2013a).

QTMR's ECI stage 1 and CIOB require the development of a risk register which is agreed upon by the client and contractor.

AIA, AEC (UK) and NATSPEC do not provide detailed advice on the insurance topic. However, AIA does warn that traditional insurance schemes might not be suitable for IPD (AIA, 2007) and AEC (UK) adds that properly communicating and tracking ownership can avoid risks of conflict (Coombes, et al., 2012), which might also help to reduce the need for customised insurance. If the ownership of each element is well defined, then each participant is liable for the elements they own and traditional forms of insurance may apply.

5.15. Additional Remarks - Staffing/Education

This section is based on information about educating the labour force which is connected to the third objective of project 2.24: Reduce the skill gap.

NATSPEC highlights that it is the contractor's and consultant's responsibility to obtain trained personnel needed to successfully use BIM for a specific project (NATSPEC, 2011).

QTMR already includes requirements to up-skill the labour force in any contract valued over AUD100 million which can be further specified in the deed (QTMR, 2009b), through for example the ECIs Skill Development Plan (QTMR, 2009e). NSW RMS also has the possibility of requesting an Enterprise Training Management Plan which has to be implemented by the contractor (NSW RMS, 2013c).

MRWA might require an Industry Participation Plan for projects where new technology transfer may be developed or significant new or increased capabilities may be developed to enhance the skills of locally based staff. This policy aims to maximise opportunities for local industry (MRWA, 2014) and might include workshops with local staff and subcontractors on the use of new information technologies.

Therefore, at least for large projects where it is likely that BIM will be implemented, these clauses could potentially be used to define a training program that helps up-skill the labour force involved in the project. To this end, the **AIA** BIM-PF can be used to establish parameters for any training or support program that will be implemented to any collaboration strategy or technical requirements (AIA, 2013c).

6. Conclusions & Recommendations

Contract agreements, manuals and procurement guidelines from QTMR, NSW RMS, MRWA, CIOB, AIA, AEC (UK) and NATSPEC were reviewed within the framework of the 3xPT Strategy Group *Integrated Project Delivery: First Principles for Owners and Teams* report. The research team focused the analysis on 14 topics considered key to the implementation of IPD principles and BIM/VDC in infrastructure construction projects.

With the exception of the AEC (UK) which only covered 9, all organisations cover 11-13 topics. However, the key difference between these organisations is the level of detail to which each topic is addressed and whether the way in which they are addressed is compatible with IPD principles and BIM/ VDC.

It was found that many current practices in Australian transport agencies are compatible with IPD and BIM/VDC. However, new issues must be considered in order to facilitate more integrated project environments and the use of new digital technologies that foster collaboration.

In general, ECIs were found to be the most IPD-compatible contract model from those studied. QTMR for example includes the possibility of integrating the sub-contractors at an earlier stage of the project (QTMR, 2009f). This team is normally formed by at least the client, principal contractor and designer. In NSW RMS' ECI all participants are *causally responsible for the acts and omissions (including breaches of this document) of the other as if those acts or omissions were its own* (NSW RMS, 2013d). This would encourage a no-blame culture by sharing the risk of non-performance; one of the basic principles of IPD (AIA, 2007). ECIs also include the development of a "relationship management plan" which aims to create a more collaborative culture based on shared core values and relationship goals (QTMR, 2009c; QTMR, 2009e). The ECI workshops also contribute to this end and fall under the Level 1 described by the ACIF-APCC Project Team Integration Workbook (2014), where Level 2 includes all senior staff of the contractor, designer, and sub-contractors and Level 3 are on-site job captains, foremen and supervisors. These are just a few of the characteristics of the ECI contract that were found to be compatible with IPD.

D&C contracts can be made more "IPD-friendly" by for example: (i) increasing client's involvement (and reflecting this in the project agreement); (ii) changing the compensation model to link financial benefits to project goals that can promote greater collaboration; and (iii) using open book accounting for project cost to foster client's collaboration throughout the life-cycle of the project; and (iv) including clauses that address risks in such a way that the BIM models can be integrated throughout the project phases.

The following section comprises a suite of recommendations for: (i) modifications/expansion of current documentation, roles, processes, and outputs; and (ii) new considerations on the same topics, plus metrics and classifications.

6.1. Modifications/Expansion of Current Practices

6.1.1. Documentation

- **Contract Agreement**: Current contract agreements can be used by adding new documentation (section 6.2.1) as addendums and adding clauses that: (i) require all subsequent agreements to include the developed protocols; (ii) reflect confidentiality and authorship of each model element as per data sharing protocol; and (iii) require that all parties include a copy of the latest version of the protocol in the model itself

- **Scope of Works and Technical Criteria:** Modify to include similar considerations as those in the CIOB Working Schedule and Planning Method. Alternatively, adding a section titled BIM Execution/Management Plan (see AEC (UK) approach in section 8.3.1), where contributions from subcontractors should also be considered
- **D&C Deed Schedule:** Linked to LODs and Model Elements (see section 5.1.1)
- **Contract Program/Preliminary Design Report:** Include newly developed metrics, KPIs and success criteria
- **Relationship Management Plan:** Use to establish collaboration standards across all project types that motivate collaboration and as a basis for project integration evaluation (already used by QMTR in their ECI).

6.1.2. Roles

- **Project Verifier:** Expand the responsibilities of this role to include BIM coordination and verification (existing NSW RMS and MRWA role) while continuing as an independent external consultant. This would be an alternative to creating a completely new role (e.g. section 6.2.3).
- **Design Manager:** Expand responsibilities to include BIM coordination activities across design and construction phases (existing role in MRWA across the two phases).

6.1.3. Processes

- **Tender Selection Criteria:** Expand non-price criteria to include past performance in integrated project environments and more interactive contract models, technical skills of the project team as well as commitment to an integrated approach. ECI-type workshops can be a tool for this evaluation
- **Bonus Clauses:** Expand benefit sharing clauses to other types of contracts and agencies (already used by QTMR and NSW RMS). Base these on clear KPIs and defined success criteria related to project goals. Linking financial benefits with project goals can increase collaboration and integration across the project
- **Integrated Project Environment Workshop:** Include efforts to: (i) facilitate all parties involved to understand and agree to limits of use (through for example authorised uses); (ii) encourage and protect the ownership of the data which often gains value with file sharing and collaboration; and (iii) create commitment to a more integrated and collaborative way of working (currently branded as “pre-start conference” or “kick-start workshop”)
- **Indemnification**: Review indemnification language included in the contract documents closely with legal and insurance counsel to avoid uninsurable obligations
- **Skill Development Plan/Enterprise Training Management Plan**: Use as tools to reduce the skill gaps on a project-by-project basis
- **Regular Update Meetings:** Use for project health check, address changes to protocols and works, and should comprise at least: client representative, contractor’s design manager, contractor representative, subcontractors (if relevant) and the project verifier (if required)
- **Risk Apportioning:** Agree upon risk apportioning in the contract agreement; ideally shared equally among all participants.

6.1.4. Outputs

- **Systems for Design Development and Data Management**: Select based on project specific considerations such as scale, cost and level of effort needed for new users; as long as the output is compatible with asset management systems. Open source systems or most commonly used software might have preference. See NATSPEC (2011) for more technical recommendations

- **Submissions:** Require in PDF format, instead of requesting all approved submittals and other required documents in paper-based formats. Drawings to be submitted in native and IFC formats while as-built drawings can be delivered as PDF files with fully bookmarked pages and design intent models in PDF and DWG format
- **Final Submission**: Clean data for final submission so only asset management and monitoring relevant information is required as specifically detailed by the client at project inception. Language such as "all relevant data" to be avoided in the contract agreement, payment schedule and milestones. This would significantly reduce storage needs and post-contract data handling, and facilitate future accessibility of the relevant information.

6.2. New Considerations

6.2.1. Documentation[11]

- **BIM Protocol**: Develop at the earliest project stage possible. This document can be added to contract agreements as an addendum that redefines relevant terms. To include: (i) a strategy to manage changes (processes to document the receipt and agreement of changes); and (ii) methodologies and technologies. Other items to be specified may include: agreed parameters regarding BIM platform(s); administration and maintenance; source of "truth" for all data; interoperability criteria; data transfer protocols; level of detail development by phase, and tolerances for BIM authoring tools; data integration; and collaborative team workflow environments, among other
- **Data Sharing Protocol (internal and external)**: Addressing confidentiality, data security (this can also be done through a separate data security protocol for complex projects); setting adequate user rights to prevent data loss or damage during file exchange, maintenance, and archiving; authorised uses of the data; identifying clear ownership of the model elements throughout the project life-cycle; transmission, use, storage and archiving the data.

6.2.2. Metrics and classifications

- **Levels of Development:** To be defined in both technical terms and in terms of roles, responsibilities, data dates, KPIs and success criteria (see sections 5.1.1 and 8.1), for each Model Element and project phase
- **Skills Matrix:** Include all relevant parties (incl. subcontractors) to assign responsibilities related to primary functions to different roles. This matrix is to be informed by the personal expertise needed for each individual task at each stage of development and related to primary functions: strategic (creation of standards, training, implementation, etc); management (execution plan, model audit, model coordination and content creation); and production (modelling and drawings); clearly assigned to different roles.

6.2.3. Roles[12]

- **BIM Project Coordinator**: To help set-up the project, audit the model and coordinate contributions to the model and protocols. A case may exist for this role to be carried out by an independent entity similar to the Project Verifier
- **BIM Technical Discipline/Trades Coordinator:** To lead meetings such as MRWA's trade coordination meeting with subcontractors. This role would facilitate the

[11] For specific recommendations on how to develop these protocols please refer to sections 5.8, 5.9, 8.3.8, 8.3.9 and 8.3.11. For simple projects these protocols can be integrated into a single document.

[12] In small projects several of these roles can be carried out by the same individual.

coordination BIM development, standards and data requirements of technical disciplines; lead the technical discipline BIM team in its documentation and analysis efforts; coordinate internal and external BIM training as required; and facilitate team "buy-in" for project overall goals, systems and integrated/collaborative approach

- **BIM Strategic Coordinator:** May manage several small projects and hand-offs from service suppliers and between phases as well as managing knowledge transfer across projects and actors.

6.2.4. Processes

- **Element Ownership and Handing-off Procedures:** Clearly define these issues to enable the use of current insurance arrangements, by having clearly defined authors responsible for evaluating, mitigating and resolving any potential conflicts found by any other user
- **Culture:** Encourage a no-blame culture
- **Common Data Environments**: To facilitate collaboration and data management. The system classification proposed by AEC (UK) (Work in Progress (WIP); Shared; Published; Archive) offers a structured and easy way of organising the data and information. Additionally, user manuals and information such as what the system is intended to achieve and how the system will impact the role of the project participants can improve acceptance by the project team.

6.2.5. Outputs

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

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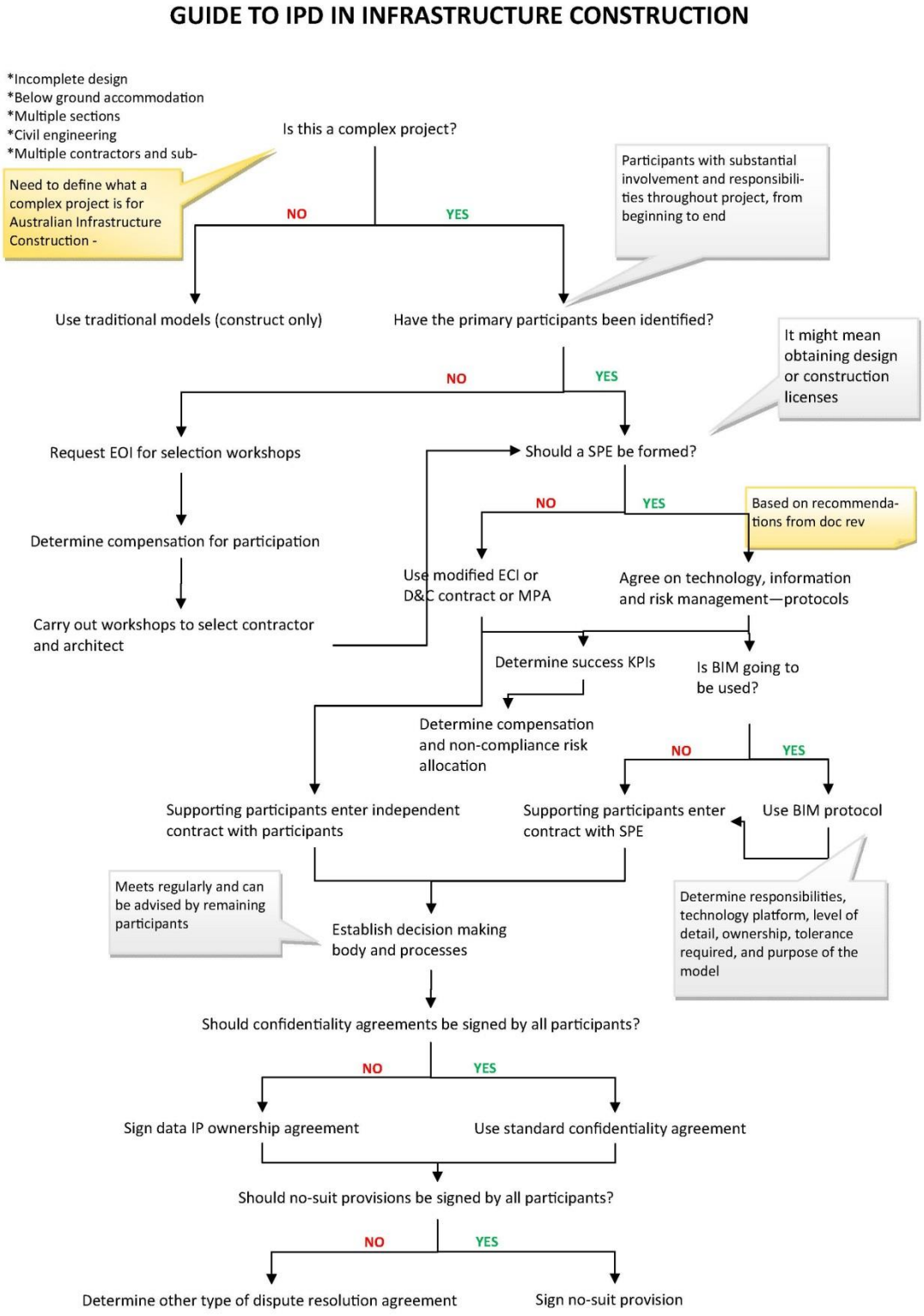
8. Appendices

8.1. CIOB Appendix C, Table 1: Levels of Development, Design and Use (CIOB, 2013a)

Table 1 - Levels of Development, Design and Uses

C1 Design Level of Development	Design Stage	Geometry	Content	Analysis	Cost Control	Time Control	Licensing and Approvals	Construction	Other Uses
1	Preparation	Conceptual	Overall massing indicative of area, height, volume, location and orientation	Conformity with general performance data	Estimating based upon cost per square metre, per cubic metre, or other conceptual standard such as per hospital bed, per hotel key, etc.	Low density project phasing and overall predicted duration.	May be used to generate drawings sufficient in detail for permission for development in outline and similar licensing		
2	Design	Approximate	Generalised systems and assemblies that indicate approximate quantities, size, shape, location and orientation, including product information where available	Conformity of systems and Design Elements with general performance criteria, including energy usage	Estimating based upon approximate data for area, volume and quantity of Element of Design	Low density timing of major Design Elements, zones of operation, project phasing and overall predicted duration.	May be used to generate drawings sufficient in detail for development control and similar licensing		
3	Pre-construction	Precise	Design Elements and assemblies accurate in size, shape, location, orientation and quantity, including product information where available	Conformity of systems and Design Elements with specific element-related performance criteria, including energy usage and sustainability	Estimating based upon approximate data for area, volume and quantity of Element of Design	Low density timing of Design Elements, zones of operation, project phasing and overall predicted duration.	May be used to generate drawings sufficient in detail for building control and similar licensing	May be used to generate traditional construction drawings, specifications and schedules	
4	Fabrication	Detailed	Design Elements and assemblies accurate in size, shape, location, orientation and quantity, with complete fabrication, detail and product information	Conformity of systems and Design Elements with specific element-related performance criteria, including fire control, health and safety, energy usage and sustainability	Estimating based upon standard rates for measured data for items, linear measure, area, volume and quantity of Design Elements	Low and Medium density timing of Design Elements, zones of operation, project phasing, methods of construction, phased access and completion, key dates and overall predicted duration. High Density planning of construction in the short term	Tender and bidding	The information comprises a virtual model of the Design Elements and is suitable for construction purposes	
5	Construction	Recorded	Design Elements modelled as constructed assemblies accurate in size, shape, location, orientation and quantity and resources, with complete fabrication, detail, product information, cost and time data	Changes and design development during construction,	Predicted Cost in accordance with Clause 53. Current Value in accordance with Clause 54, and Final Value in accordance with Clause 56	High Density planning of construction including all resources and productivity planned to be achieved. Productivity achieved and resources used in accordance with Progress Records and contemporaneous time management, including delay and disruption analysis.	Occupational permits, fire authority and Health and Safety Executive permissions	The information comprises a virtual as-built model of the Design Element and is relied upon for retrospective analysis	Actual record of resources used and productivity achieved, for benchmarking and feedback.
6	Use	Recorded	As constructed Design element assemblies accurate in size, shape, location, orientation and quantity	Using, maintaining, altering and adding to the project in conformity with licensing agreement, if any.			Occupational permits, fire authority and Health and Safety Executive permissions	The information comprises a virtual as-built model of the Design Elements and is relied upon for cooperation and maintenance	Can be relied upon for all purposes in connection with facilities management and the future use and maintenance of the project

8.2. IPD Schematic Guide Based on AIA (2007)



8.3. Detailed Findings by Topic

This section should be considered literal quotes from the original documents.

8.3.1. Service Scopes

QTMR has moved to adopt a common approach to the Scope of Works and Technical Criteria (SWTC) across D&D, ECI and Alliance contracts, covering road and bridge requirements where design and construction are undertaken under a single contract. This new approach includes the use of a generic project brief which can be adapted to specific projects (QTMR, 2011).

NSW RMS establishes in the General Conditions that the contractor must design and construct the works, where the extension of the design obligations is specified in the contract (Clause 39). The works are described in the brief of the contract information and in the contract documents, including: requirements for fit for purpose status, requirements to achieve effective and efficient use and operation of the works, and the specific work contemplated in the contract (NSW RMS, 2013c).

MRWA also uses the SWTC to outline the service scope as minimum requirement. Clause 2.1c adds that the contractor must *ensure the design and construction of the project works provide a safe road and rail environment for all users* (MRWA, 2014).

The **CIOB** contract defines "the model" as the digital representation of part of the physical and/or functional characteristics of the works. The Working Schedule and Planning Method Statement defines the activities with adequate duration, linked to the construction activities to which they relate for submittal of acceptance, period of consideration, correction and reconsideration; for each design stage and level of development. If the contractor is to develop the design, then it must record the production of data for each business day from the date of commencement until the date of substantial completion, including: activity description, contributor's name, status and name of each employee allocated to the activity in progress and the hours worked by each, quality of the works completed, etc (CIOB, 2013a).

The **AIA** Building Information Modelling and Digital Data Exhibit (BIM&DDE) E203–2013 has sections explaining how the terms of the exhibit relate to the underlying Agreement into which it is incorporated, how it is applicable across the Project, and the potential impact subsequent protocols may have on the Parties' scope of services, scope of work, and related compensation (AIA, 2013f). Clause 1.3 of the BIM&DDE for example, requires all parties to notify all other parties within 30 days of receiving the document if the protocols therein established will change their service scope included as a part of the initial agreement. Otherwise, all rights to claim any adjustment to compensation, contract sum, and schedule or contract time as a result of the protocol are waived. Upon notice, the protocol has to be negotiated between parties (AIA, 2013b).

The **AEC (UK)** Project BIM Execution Plan identifies key project tasks, outputs and model configuration. It defines how the model is to be carried out and the formats to be used. As a minimum it must address and define: (i) goals, uses and aspirations along with the workflows required to deliver them; (ii) standards to be used and any deviations from it; (iii) software platform and how interoperability issues are to be addressed; (iv) project leadership, roles and responsibilities; (v) meetings frequency and attendees; (v) project deliverables and the formats for delivery and exchange; (vi) project characteristics (size, location, division of work, schedule, etc); (vii)

coordinate system for all BIM data; (viii) data segregation (model organisational structures to enable multi-discipline, multi-user access and project phasing as well as ownership of project BIM data; (ix) checking/validation processes of drawings and BIM data; (x) communication protocol (frequency and form of exchange); and (xi) project review dates (with full design team). This execution plan can be used as a pro-forma for standard projects and include additional clarifications for complex projects (Coombes, et al., 2012).

NATSPEC suggests that a structured process should be used from early project stages to define the requirements for using BIM on the project. This effort should involve the client and project team and include a BIM Management Plan (BMP) describing to as much details as possible how the project will be executed, monitored and controlled in regards to BIM in order to satisfy the requirements recorded in a Project BIM Brief. The brief is to identify the standards to be used, the expected use of the model and the stakeholders. The BMP shall align the project acquisition strategy needs and requirements with the Program for Design (PFD), client technical standards, team member skills, construction industry capability, and technology maturity. This document should be updated regularly to ensure the project remains on schedule and meets the briefed requirements. Further to this, the guide offers a list of potential uses of BIM to be considered by the client when writing the Project BIM Brief (NATSPEC, 2011).

8.3.2. Subcontracts

Treatment of subcontractors and suppliers is used as an example of non-price selection criteria in **QTMR**'s ECI contract (QTMR, 2009d). Once the contract is awarded the contractor must submit a proposal for the subcontractor which is then approved by the client (QTMR, 2009f).

The new version of the **NSW RMS** general conditions presents a short list (19 items) of mandatory requirements to give the contractor and subcontractors more flexibility in their commercial arrangements. These include cooperation (clause 3), evaluation and monitoring (clause 6), intellectual property (clause 23), confidentiality (clause 24) and subcontractor requirements (schedule 9). Under these conditions the contractor is solely responsible for all subcontractors and is liable for their acts and omissions, as if such acts and omissions were those of the contractor. Additionally, the contract information may include a list of preferred subcontractors in which case the contractor may only choose subcontractors from the provided list (NSW RMS, 2013c).

MRWA establishes that individual subcontracts should not exceed a value of AUD200,000, although consideration should be given to the design requirements. The contract also provides lists of minimum requirements related to the subcontractor's certifications, personnel, capabilities and knowledge for each example discipline subcontracted. In all cases, the contractor is liable to MRWA for the acts and omissions of the subcontractor, as if they were their own. The contract also stipulates that MRWA can require subcontractors to be represented in the project review group (MRWA, 2014).

Contributions by subcontractors are included in the definition of design contribution and the works used in the **CIOB** contract. However, more detailed information about the conditions of contract for subcontractors are defined in the CIOB Complex Projects Subcontract. This provides that the subcontractor is to retain copyrights and all other intellectual property and moral rights over the subcontractor's design, it has the obligation to perform and comply with the special conditions in the contract in so far as they relate and apply to the subcontracted works. However, there are no special

conditions for nominated subcontractors in this contract. If the client wishes to use a specific subcontractor this should be clearly defined and made a term of contract by being set out in the special conditions. Finally, any designs made by the subcontractor are included in the contractor's design and therefore the subcontractors are to indemnify the contractor against any deficiency in its design and warrants to the employer the sufficiency and quality of its design (CIOB, 2013a).

Clause 1.2 of the **AIA** BIM&DDE establishes that all participants utilising digital data are to include this document in their agreements and all subsequent contracts for that project (AIA, 2013b). This can be further reinforced through general *flow-down* provisions in the prime agreement prior to the time sub-agreements are executed (AIA, 2013f). The AIA Guide, Instructions and Commentary to the 2013 AIA Digital Practice Documents (GIC-DPD) also provides alternative language for this clause as to hold project participants accountable in case of failure downstream to the digital data and BIM protocols, making them liable for indemnification due to breach of contract while keeping the subcontractors and other project participants not liable for any damages (AIA, 2013f, p. 8).

The **AEC (UK)** does not mention subcontracts in any of the documents analysed.

NATSPEC requires that equipment used by the subcontractors during the on-site coordination meetings must meet the requirements of the software being implemented so as not to cause delays in modelling and redrawing. The BMP should also define the list of subcontractors using digital fabrication (NATSPEC, 2011).

8.3.3. Changes

Under **QTMR**'s General Conditions of Contract, changes to the design or the works are dealt with through variations following written communication from the client to the contractor and the contractor's assessment of viability and impact on project outcomes and cost. This contract also defines 'directions' by the client to the contractor in clause 23 as 'explanations', 'permissions' and 'requirements'. These must be given in writing, stating the client's expectations and whether the new directions will have consequences regarding time and cost so the contractor has time to respond immediately if there is disagreement (QTMR, 2005).

However, **QTMR**'s ECI contract establishes that the contractor, designer and client must consider design options and develop concepts, and agree and confirm changes to the brief during the design workshops carried out in stage 1. Changes to the relevant items of the design that may emerge during the design process, after the RAP has been developed, can be priced and negotiated with the client progressively (QTMR, 2009e). Throughout stage 2 the project management team meets at least once a month to discuss and report design reviews, changes and progress of the works, among other (QTMR, 2009f).

QTMR's D&C establishes that, to avoid the risk of different designs being held by the client and the contractor, this contract may include provisions so the contractor's offer (for those areas that differ to the client's reference design) are treated as a variation for the convenience of the contractor (QTMR, 2011).

In **NSW RMS'** D&C changes are dealt with through variations or amendments to the design documentation, in which case the contractor must ensure all relevant parties receive the correct documentation with the amendments. Variations require written notice from the contractor to the client, with the client needing to approve the said changes. These must be accompanied by a written statement certifying that the changes will not affect adversely the functionality, integrity or aesthetics of any of the elements of the contractor's work or the performance standards required by

this deed (NSW RMS, 2013b). The general conditions just establish that the contractor can propose a variation to the design provided by the client, as long as the variation does not affect the construction, operation or maintenance of the works (NSW RMS, 2013c).

If the changes are likely to offer significant benefits (including long-term or repeated benefits) to the client, the proposal must include: changes to the works and price, potential risk, required changes to contractual completion dates, projected changes to operation, maintenance and whole-of-life costs, benefits to the client, and benefits to the contractor. Before proceeding with the changes, both parties must agree to the financial benefits each will receive. The contract information document may have a clause (item 39 in the general conditions of contract) stating the proportion of any savings that must be shared between the contractor and the client (usually 50%) (NSW RMS, 2013c). Clause 41 of the D&C contract provides an incentive to the contractor to improve its service to the client by innovation. If the client accepts the contractor's proposal, the contractor benefits from the variation and the client benefits from the value added to the works through reduced operating or maintenance costs or other savings (NSW RMS, 2013c).

MRWA's D&C offers similar terms also dealing with changes through variations. Clause 12.2 states that *any cost savings resulting from a variation proposed by the Contractor,* and approved by MRWA*, should benefit Main Roads and the Contractor equally*. Any proposed design changes and potential cost savings consistent with *maintaining Project quality and enhancing Project life cycle costing* are discussed by the Project Review Group. This group is formed by MRWA representative and contractor key personnel such as: project manager, design manager, construction managers, safety and site environmental mangers, quality manager, communication and stakeholder engagement manager, site traffic manager, subcontractor representative and any other personnel that MRWA might deem required (MRWA, 2014).

Unless the specifications or the description of the works under the **CIOB** contract define that the contractor is to carry out the design or part of it, any changes proposed by the contractor are instructed as variations it accepted by the client. In such case the contractor retains the copyrights over the new design and grants the client a perpetual, transferable, irrevocable non-exclusive, sub-licensable, royalty-free license to copy, use, modify and reproduce the contractor's design.

The **AIA** GIC-DPD strongly suggests that the project participants should develop a process to document the receipt of, and agreement to, changes to the protocols by each participant as to avoid potential conflict. It also states that it is expected as that as the project circumstances change, the Project Participant will jointly revise and issue updated versions of the digital data and BIM protocols (AIA, 2013f). These modelling protocols should address the process by which project participants are to identify, coordinate and resolve changes to the model (AIA, 2013b).

The **AEC (UK)** establishes that all changes to the model shall be carried out as 3D modifications, rather than 2D 'patches' to maintain the integrity of the model. Additionally, people not directly involved with the development of the model and production of information should use viewing software defined in the Project BIM Execution Plan to access non-editable versions (Coombes, et al., 2012).

NATSPEC suggests that the BMP should outline the strategy for updating and coordinating changes during construction into the final BIM model deliverable files (NATSPEC, 2011).

8.3.4. Outcome/Overall Performance Metrics

During stage 1 of **QTMR**'s ECI, the contractor is required to prepare a detailed planning and preliminary design report which includes planning of the performance of the works and the design and construction of the works including, if possible, alternative materials (QTMR, 2009e). Prior to the Relationship Management meetings in stage 2, each invitee is required to score team/project performance for discussion at the meeting (QTMR, 2009f).
QTMR's D&C contract standard provisions explain that if the design brief inadequately defines performance or quality requirements, there is the risk of the contractor *under-designing* aspects of the project in order to effect savings and increase its returns within the lump sum contract. The brief details the minimum design and construction standards to be achieved, and define deliverables and standards to which the contractor is required to sign-off compliance. Therefore, these contracts use 'hold points' to ensure specifications are being met and should state that the contract administrator shall not allow works to proceed without approving these 'hold points' (QTMR, 2011).

Furthermore, QTMR's Project Delivery Systems document clarifies that for a D&C to be successful, clear performance, technical and quality criteria need to be prepared by the client for the project. These criteria must include objectives for durability, design life, operational criteria, standards of finish and aesthetics, community and environmental standards (QTMR, 2009b).

NSW RMS' general conditions require parties must meet regularly to evaluate and monitor performance of the contract. The contract program submitted by the contractor and accepted by the client must reflect the contractual completion dates and milestones, be consistent with all access, performance and coordination, schedule of works, etc. This document is to be updated at least once every month. The general conditions also provide an example form to guide the evaluation and monitoring meetings that can be developed into contract-specific performance evaluation forms (NSW RMS, 2013c).

MRWA's D&C contractor performance clause states among other things that the contractor: (i) design and construct the Project Works in accordance with the deed; (ii) *ensure that the design and construction of the Project Works are suitable for the purposes for which they are required by Main Roads*; (iii) *in addition to meeting all minimum requirements required in the SWTC, perform all of the Contractor's Obligations to ensure that the design and construction of the Project Works provide a safe road environment for all users;* and (iv) *perform all of the Contractor's Obligations in a proper, thorough, skilful and professional manner with all due expedition and in accordance with Probity Requirements and Best Practice and in all respects with the terms of this deed* (MRWA, 2014).

The design execution plan outlined in the **CIOB** contract defines the performance specifications and plan of works for the timing, preparation, submittal and approval of each design stage or design level of development (degree of completeness of a model identified by the table in section 1.1). The project time manager checks on regular basis, whatever is produced by the contractor by way of time-related information and to accept it or reject it (CIOB, 2013a).

The **AIA** IPD guide explains that IPD contracts should have collectively-defined project goals and metrics to measure performance, along with compensation models that align individual success with project success, also provide incentives to work as a team. Under these conditions, current standards of care for designers and contractors remain intact for those activities that are traditionally performed. The IPD project plan includes project metric values and reporting intervals

to monitor progress of the project. Metrics include overall performance of the project as well as the traditional cost, schedule, and scope measurements. Meeting these metrics may also be tied to financial incentives for the parties. If the goals are simply economic, standards of project duration and cost may adequately measure attainment of these goals. Objective performance criteria, such as energy efficiency of the constructed asset, are also easily determined. Quality of construction and design creativity are less easily measured. These factors may require a weighted index, comparison structures, and independent evaluators. The team also agrees on when the standards will be measured. If for example, lowered maintenance cost is a goal, the team determines when success is measured. The contribution that the project team makes to the ongoing success of the performance of the finished project due to quality of design and implementation could lead to royalty or other long term financial profit sharing arrangements for those key participants (AIA, 2007).

Furthermore, the AIA IPD guide suggests that BIMs have the ability to provide information either directly or through linked databases that can enhance and streamline a reviewing agency's ability to check the design for building code or regulatory criteria. In addition, analysis software can use the model information to generate performance or criteria analyses that validate the design (AIA, 2007). When using BIM, the model element may be analysed based on volume, area and orientation by application of generalised performance criteria assigned to other model elements (AIA, 2013f).

The **AEC (UK)** Project BIM Execution Plan must outline: geometric coordination, information and design development, drawing production, data export and method, schedule of production, and resolution if relevant, and procurement and performance/specification purposes of the BIM data. These issues need to be discussed and agreed upon prior to the commencement of work. Additionally, it needs to define the stages at which and the packages for which the BIM data is required to be delivered. The Execution Plan dictates the point at which 3D geometry ceases and 2D detailing is utilised to prepare the published output. The protocol also provides detailed recommendations for outputs compilation (Coombes, et al., 2012).

The **NATSPEC** guidelines highlight the significant added value to facility and asset management departments of owning and reusing BIM data. Therefore, the final BIM deliverables should be defined to create accurate data and refine it during project execution so the as-built BIM is submitted at practical completion for this purpose (NATSPEC, 2011).

8.3.5. Risk Management/Distribution

QTMR's General Conditions Contract Guide establishes that the contractor is liable to the client for the acts or omissions of subcontractors and their employees as if they were omissions by the contractor (QTMR, 2005). QTMR's D&C offers the possibility to novate a previous design by the client to the contractor, who can then modify it before accepting the risk involved (QTMR, 2011).

During the stage 1 of QTMR's ECI, risk management workshops are carried out to develop the stage 2 offer. The objectives of the workshops are to develop a strategy to deal with unforeseen circumstances, minimise damage caused by identified problems, identified objectives, priorities and constrains, enable more effective cost management, and improve accountability. The workshops should be facilitated by a risk facilitator who undertakes risk modelling and provides input into risk mitigation strategies. The independent estimator costs the Risk Registered (OnQ template) developed during stage 1 to determine the Risk Adjusted Price (RAP). This document records the nature, the likelihood and consequences, the agreed allocation and mitigation strategies of the risks

(QTMR, 2009e). The second stage offer can be based on either RAP or Risk Adjusted Maximum Price (QTMR, 2009c). The RAP/RAMP includes allowances for the risk allocation negotiated and agreed during Stage 1. This will depend upon the level of investigations during Stage 1 (for example, geotechnical investigation or level of design) and is dependent upon the risk profile of the stage 2 works (QTMR, 2009e). During stage 2, a second risk management workshop is carried out to review the Risk Register and include: the nature of the risk; the likelihood and consequences of risk; agreed risk allocation; and mitigation strategies (QTMR, 2009f).

NSW RMS establishes in the General Conditions of Contract that the contractor must check the contract documents and notify the client of "faults" in any contract document including the design within 21 days from receiving them; otherwise it is not entitled to any cost for delay or aborted works (NSW RMS, 2013c). However, section 7.2 of NSW RMS' ECI stipulates that the obligations of all participants that form part of the tenderer entity, are joint and everyone acknowledges and agrees that it will be causally responsible for the acts and omissions (including breaches of this document) of the other as if those acts or omissions were its own (NSW RMS, 2013d). In contrast, under the D&C contract the contractor is responsible for the care of and bears the risk of, and indemnifies RMS against any loss or damage to the works from the date of the deed until de date of opening completion or when the client has issued a written notice of completion. The aggregated liability to RMS arising out of or in connection with the contractor's work and the deed, whether in contract, tort (incl. negligence) or otherwise at law or in equity is limited to an amount which is equal to the project contract sum (NSW RMS, 2013b).

Under **MRWA**'s D&C contract the contractor assumes *overall responsibility for design, construction and maintenance risks* as described in the deed and *for all aspects of Project quality* (MRWA, 2014).

The risk distribution under the **CIOB** contract depends on the delivery model chosen. The contractor bears all the risk if it decides to use the model in a way that is inconsistent with the design level of development identified in the table of 'levels of development, design and uses' (section 1.1), and the 'design author responsible for the design element at each design level of development' table. The contractor is also to indemnify the client against any loss or damage it may suffer and against any liability, direct or consequential, in connection with the use by other design users to the contractor's contribution. If the whole of the works are designed by the contractor, it remains solely responsible for the suitability and integrity of the selected software and any information, drawings, specifications or other information extracted from any model (CIOB, 2013a).

In case the client provides a model which is identified in the special conditions to be developed by the contractor, the client is responsible for the specified accuracy of that design to that design stage or status. If nothing is stated, it should be assumed that the model was provided as reference only and should not be relied on (CIOB, 2013a).

Additionally, the CIOB contract includes a list of foreseeable occurrences which may delay the progress of the works and it highlights the key role played by the Project Time Manager in the management of risk, mitigation, recovery of culpable delay and acceleration (CIOB, 2013a).

The **AIA** IPD guide recommends sharing the risk of non-performance to promote collaboration across traditional roles and responsibilities. Therefore, IPD agreements often spread the risk of non-performance across all direct participants. In this way, the designer may directly bear some risk of constructor non-performance, and vice versa. In negotiating agreements and building project team

relations, this issue is recognised and addressed up front. The participants necessarily negotiate the level of risk sharing they are jointly comfortable with, on a project-by-project basis (AIA, 2007).

When using BIM, clause 3.1.2 of the AIA BIM-PF establishes that, where conflicts are found in the model, regardless of the LOD, the participant that identified the conflict must contact the model element authors and the participant responsible for the model management. Upon notification the model element author must act promptly to evaluate, mitigate and resolve the conflict. However, it doesn't specify the bearer of the risk (AIA, 2013c).

The **AEC (UK)** recommends that, as part of planning BIM data exchange methodologies, it may be beneficial to test the exchange workflows prior to commencing the project models to help establish efficient ways of collaboratively exchanging information as well as reducing the risk of problems later in the process (AEC (UK), 2012b). Additionally, model files should be issued in conjunction with verified 2D document submissions to minimise the risk of errors in communication and all team members should save their models regularly (at least once per hour) to ensure all users have access to up-to-date information and that risk of data loss is reduced. (Coombes, et al., 2012).

NATSPEC recommends that all technical disciplines (Design) are responsible for their data integration and data reliability of their work and coordinated BIMs. However, it explains that the acquisition strategy, which is part of the contracts agreement, defines the integration or separation of risk and responsibilities for the design and construction contracting entities; and therefore, the Level of Development (LOD) and division of responsibilities, such as the number of BIM Managers (there may be only one BIM Manager throughout the project if D&C is used, and two, a Design and a Construction BIM Manager if DBB is used). Similarly, contractually defined risk will also determine whether there are separate design intent and construction BIM models, or whether they can be combined into one model (NATSPEC, 2011).

8.3.6. Collaboration/Coordination

QTMR's Project Delivery Systems manual states that partnering with all project participants should be embedded in all construction projects regardless of the delivery method chosen. This document suggests that for any project of expected cost equal or greater than AUD10 million, extended partnering[13] should be included unless Alliance is chosen as the delivery method, and partnering should be offered to the successful tenderer of any project costing AUD3 million or more (QTMR, 2009b).

Under QTMR's ECI, client and contractor representatives form a 'Relationship Management Team' and are required to participate in relationship workshops to develop a team approach to stage 1 work (QTMR, 2009c). During the first workshop, the team develops the 'relationship management plan' which includes core values, guiding principles, and relationship goals and objectives later used for monthly assessment and measurement through the 'ECI Health Assessment Form'. Therefore, the client, contractor and designer establish a clear and concise communication protocol within the team during stage 1 (QTMR, 2009e).

Design workshops are also carried out to review and agree on the design direction for stage 2, and are facilitated by external facilitators (QTMR, 2009e). During stage 2 the construction team is formed

[13] *Extended partnering is a formal process used to facilitate greater team participation and communication outside of the contractual process. It is used to develop a co-operative approach between all parties to the contract to achieving best for project outcomes*

by: Project Manager (Contractor's Representative commonly involved in stage 1 as well), Foreman, Project Engineers, Quality Representative, Surveyors, Works Supervisors, Community Liaison Officer, Design Manager, Chief Structural Engineer, Hydraulic Engineering Team Leader, Geotechnical Engineering Team Leader, and supporting specialists that may also be required (e.g. geometric design, pavement design, road design, environmental and electrical). Once the construction team is in place the contractor is responsible for organising the 'Pre-Start Conference' with the client to clarify and determine the roles, responsibilities and delegations for the construction of the works. This conference is then followed by the partnering workshops to develop the construction strategy (QTMR, 2009f).

Following this, the monthly project management team meetings provide a forum for the client to work with the construction team to resolve issues as they arise (written reports of these meetings are circulated every month). The relationship management meetings, carried out during stage 2, are attended by the client, the Project Manager and the Foreman. If an issue/dispute arises and cannot be resolved through the 'Dispute Resolution Process', either the client decision and conference decides the issue or Dispute Resolution Board can be used (suitable for larger contracts) (QTMR, 2009f).

Under QTMR's D&C contract it is also possible to have design conferences for tenderers to seek clarification on issues and confirm if alternatives would be acceptable. These events also provide an opportunity for initial relationship building. In case of conflict, the D&C manual recommends the engagement of a Dispute Resolution Board (DRB) formed by engineers rather than lawyers so the representation is focused on practical and commercial outcomes (QTMR, 2011). Additionally, site meetings are also held monthly by the contractor and client representatives (QTMR, 2009f).

The figure of Design Review Manager is sometimes used to coordinate the submissions throughout the different stages. Therefore this role is carried out by the same person from tender preparation through to completion (QTMR, 2011).

NSW RMS General Conditions highlight that all the parties must do all they reasonably can to cooperate in all matters relating to the contract. The parties must decide jointly who will participate in the evaluation and performance monitoring meetings, which may include subcontractors, suppliers, consultants, and if appropriate, representatives of government authorities. In addition, the contract requires a start-up workshop to encourage all parties involved in the works to cooperate towards achieving the project goals (NSW RMS, 2013c).

Section 7.1 of NSW RMS' ECI establishes that the contract cannot be interpreted as the participants being partners, joint venturers or any other fiduciary relationship (NSW RMS, 2013d).
NSW RMS' D&C contract explains that one of the objectives of the start-up workshops is for the participants to understand and commit to a culture of cooperation, as well as to reach a consensus on a framework for cooperation (communication arrangements) (NSW RMS, 2013a). Additionally, the project design group (comprised by at least: client representative, contractor's design manager, contractor representative, and the project verifier) to cooperate in a manner that fosters open communications to consider the status, quality and any other matter required of the design documentation. The contractor must also ensure the attendance of any design consultants, proof engineers and any other person that the project design group reasonably requires based on the elements of the design documentation being considered (NSW RMS, 2013b).

There is also a close-out workshop to review the management of the contract, as well as to collect and provide feedback to the parties to enable them to improve the overall communication and management process for any possible future contract (NSW RMS, 2013c).

In **MRWA**'s D&C, the contractor is responsible for holding regular design meetings that include not only its team but design consultants and verifier and are coordinated by the design manager. Minutes of these meetings must be provided to MRWA within 48 hours and the client representative is entitled to attend such meetings. The contractor must consult with the Main Roads' Asset Manager and provide monthly copies (hard and digital copies) of the revised program (MRWA, 2014).

Clause 23 of the D&C contract also states that MRWA *intends to establish a partnering arrangement with the Contractor* to *encourage the parties to positively work with each other and with key stakeholders in an open, cooperative and collaborative manner and in a spirit of mutual trust and respect.* To do this, partnering workshops are conducted to capture learnings from the project. However, *nothing in the arrangements set out in this clause 23 is intended to create, nor will it be construed as creating, any partnership, joint venture, fiduciary obligation or any other obligation or liability under this deed or concerning the Project other than the express obligations in this clause 23* (MRWA, 2014).

Under the **CIOB** contract, the Working Schedule and Planning Method Statement are submitted for acceptance by the client indicating the relevant data dates (date at which the status of the data is established in an electronic file) for every activity planned to be started. This should include the resources planned to be used, productivity expected to be achieved, quantity of work planned to be completed, calculated duration and the planned value. The planning method statement is also to include the design execution plan if required by the description of the works (CIOB, 2013b).

The project time manager (identified in the contract agreement, appointed by the client or the contract administrator) coordinates the submittals made by the contractor and the archive, unless the data is automatically maintained in a common data environment. This role also checks and evaluates the progress records. The design coordination manager is the person identified in the contract agreement as being responsible for maintaining a database of submittals of any contractor's design contribution, and for the coordination and maintenance of the client's BIM (CIOB, 2013a).

Where the contractor is to prepare the BIM, the design coordination manager must be appointed by the contractor who would produce the design execution plan for the contract administrator's approval. Where the works are designed by the client or under the client's direction, the party responsible for the maintenance of the model will be the employer's design coordination manager (usually working under the direction of the lead design consultant) to ensure proper coordination of that contribution and to maintain a database of submittals (CIOB, 2013b).

Clause 1.4 of the **AIA** BIM&DDE establishes that each model element[14] author is responsible for managing and coordinating the development of the specific element to the level of development (LOD) in the project milestone, regardless of who is responsible of providing the content. Clauses 3.5, 4.5 and 4.8 assign the architect (unless noted otherwise) as responsible for the development of

[14] Under this agreement a model element is constituted by graphical representations and any other data sets as specified in the protocol (AIA, 2013f).

coordination and sharing procedures for all digital information (AIA, 2013b). Clause 1.3 of the BIM-PF establishes the communication protocols, collaboration meeting schedule and colocation requirements (AIA, 2013c). This document also leaves the collaboration strategy as a fill point so that individual teams can record their preferences for project initiation, ongoing collaboration, and regular forms of communication (AIA, 2013f). Clause 3.2 establishes the LOD, model element author and notes for each model element at each project milestone (AIA, 2013c).

Under models consistent with IPD, communication methodologies and technologies have to be identified and key parameters agreed upon regarding: BIM platform(s); administration and maintenance of BIM(s); source of 'truth' for all data; interoperability criteria; data transfer protocols; level of detail development by phase; and development of tolerances (AIA, 2007).

The **AEC (UK)** BIM protocol suggests BIM Project Review Meetings to take place regularly to ensure model integrity and project workflow is maintained. Additionally, clear guidelines should be developed for internal and external collaborative working to maintain the integrity of the electronic data and identify clear ownership of the BIM elements/objects through the life of the project (Coombes, et al., 2012). Additionally, it suggests the creation of a 'Skills Matrix' where responsibilities related to primary functions: strategic (creation of standards, training, implementation, etc); management (execution plan, model audit, model coordination and content creation); and production (modelling and drawings), are clearly assigned to different roles. The protocol stresses the importance of having three roles: the BIM Manager (strategic), Coordinator (management) and the Modeller (production). In small projects, all three roles could be carried out by a single individual. The management function is project and BIM-specific; the coordinator helps set-up the project, audit the model and coordinate with all collaborators. This role may manage several small projects. Finally, the modeller is a technically skilled role and project-specific (Coombes, et al., 2012).

The Project Leader should also initiate a 'kick-off' meeting where the BIM goals and the Project-wide Execution Plan are defined, involving key stakeholders and considering the BIM requirements for the full lifecycle of the project (Coombes, et al., 2012).

NATSPEC recommends the use of BIM authoring tools, data integration, and collaborative team workflow environments to develop and produce project information and documentation as required for submittals in the client's submission Instructions. BIM use should be maximised for project reviews, decision support, design analysis, and quality assurance during all phases of the project (NATSPEC, 2011).

The guide outlines two BIM Managers (design and construction) and as many as necessary Technical Discipline/Trade Lead BIM Coordinators:

- The design BIM Manager is to be responsible for development and compliance with the approved design BMP; coordinating software training and file management; assembling the information for the coordination meetings and facilitating its use; coordinating between disciplines and ensure they are operating properly; and ensuring that the design deliverables specified in the contract are provided in conformance with the formats specified, among other.
- The Construction BIM Manager is responsible for: the construction BIM model and any information developed during construction; coordinating software training and establishing software protocols; coordinating of teams; coordinating construction sequencing and scheduling activities that are integrated with the BIM; facilitating the use of the model by all

trades; and coordinating update of as-built conditions in the Final Model deliverable, among other. The Coordinators are responsible for: coordinating technical discipline BIM development, standards, data requirements, etc. as required with the Design Team BIM Manager; leading the technical discipline BIM team in its documentation and analysis efforts; coordinating internal and external BIM training as required; and coordinating trade items into the Design BIM (depending on acquisition plan) (NATSPEC, 2011).

There should also be a 'Collaboration Standard' document mandated by the client addressing: lines of responsibility, modes of communication, reporting procedures, approval and sign-off procedures, information management and exchange protocols, model sharing protocols, model coordination procedures, and model and drawing versioning procedures (NATSPEC, 2011).

8.3.7. Selection Process and Criteria

QTMR's ECI uses a combination of price and non-price for their principal contractor and designer selection criteria at different stages. The designer can either be nominated by the contractor during tender or be novated by the client to the contractor based on the concept planning phase (QTMR, 2009c; QTMR, 2009e). The tender phase is based on the Invitation for Tender, Conditions of Tender and Tender Forms QTMR standard documentation. Mandatory criteria include: pre-qualification and financial capacity, appropriate profit margins and current commitments. There should be 3-5 non-price criteria which can include: relevant experience, track record, methodology, supply chain management, proposed approach, and resources (QTMR, 2009c). The ECI selection process is based on the analysis of the submitted tender documents addressing the mandatory and non-price criteria. This analysis is done by a Tender Assessment Panel (TAP) and followed by interactive workshops with nominated key team members, including at least the Project Manager, Design Manager and the Construction Manager. These workshops aim to evaluate the tenderer's commitment to integrated teams and relationship management principles, among other. Finally, once a preferred tenderer has been nominated by the TAP, the cost plan for stage 1 is submitted to a financial audit check by an independent auditor (QTMR, 2009d)

QTMR's Standard Contract Provisions for D&Cs also add that staffing requirements should be determined early in the project and documented in the Project Plan. Normally, 15% of the design is part of the tender selection criteria and a Risk Adjusted Comparative price is used for the tender evaluation (QTMR, 2011).

NSW RMS' Engineering Contract Manual section 3.6 provides general guidelines on how to assess tender submissions. Tenders in traditional engineering contracts are assessed by a Tender Assessment Committee appointed by the Branch Manager and, for projects valued over AUD1 million, it is formed by at least three people including at least two with contracting experience of which one is an RMS Officer (Project Manager) and at least one external party (e.g. government representative, consultant, etc). If the project value is under one million, then the panel can be formed by two people with contracting experience of which one is to be the RMS Project Manager (NSW RMS, 2011).

It is RMS policy to award contracts to organisations whose tenders are assessed as offering the best value for money: tender that satisfies the assessment criteria in the information documents, as well as other tender details that require evaluation and is expected to result in the satisfactory completion of the specified work, at the specified quality, to the specified environmental and safety

standards, within the specified time, for the lowest price and performed in the spirit of cooperative contracting. Weighted scoring is not seen as necessary and should only be used for larger projects or for complex projects with critical issues involved such as work under traffic, track possession, inner city work and similar. The decision should be based on a 'Comparative Price Assessment' which is to include an allowance for obvious risks that can be quantified as an outcome of the detailed tender assessment and a sensitivity analysis. Recent performance (in terms of successful project delivery to the specified quality, environmental and safety standards; within time and cost, and performed in the spirit of cooperative contracting) and current financial position is considered to be one of the most important assessment criteria. If weighted scoring is used, weightings should be allocated to the non-price criteria listed in the information documents in relative proportion to the identified risks and is carried out independently of price (NSW RMS, 2011).

However, for D&Cs weighted scoring should be used. It is seen as necessary to use weighted scoring where tenders involve teams of contractors and consultants and the success of the project is dependent on design outcomes. For larger and complex projects and where a detailed tender assessment is undertaken price should be scored with a weighting in the range 80% - 90% (NSW RMS, 2011).

MRWA issues an invitation to expression of interest to become a proponent. Three-Four proponents are invited to submit a proposal that is *sufficiently developed to form the basis of the selection of a preferred proponent*. The proposals are evaluated by a MRWA team who provides recommendations to the Executive Director Infrastructure Delivery as to the preferred proponent. The executive director endorses the recommendation which is then approved by the Commissioner of Main Roads and the Western Australian Minister of Transport (MRWA, 2014). The D&C contract does not however explain the criteria used for the described selection process.

The **CIOB** contract focuses on post-contract award documentation.

The **AIA** IPD guide only mentions that careful selection of the participants is key to: (i) achieving the level of comfort that project information exchanged will be used only for the project purposes; (ii) minimise the likelihood that disputes will arise over whether the goals have been achieved; and (iii) avoid conflicts of interest related to price (AIA, 2007).

The **AEC (UK)** does not address the selection process and criteria.

NATSPEC recommends that part of the evaluation criteria for the selection of consultants and contractors should be based on the qualifications, experience, and previous success in BIM coordination of the proposed Design BIM Manager, the Design Team, Construction BIM Manager, contractor and major subcontractors. This should be then specified in the BMP with the contact information for the following: (i) Design stage: BIM Manager; Technical Discipline Lead BIM Coordinators for all major disciplines (Civil, MEP, Structural, etc); and (ii) Construction stage: Construction BIM Manager and Lead Fabrication Modellers for all trades. This should be done in the BMP. They also recommend the clients to grant the contractors with access to the Design BIM during bidding and construction (NATSPEC, 2011).

8.3.8. Technology Protocol

QTMR does not provide information regarding the creation or existence of technology protocols.

NSW RMS establishes in the general conditions that unless the contract specifies or the client instructs that the contractor use a particular work method, the contractor is solely responsible for determining the work method and requirements for all temporary work (NSW RMS, 2013c).

MRWA D&C contract does not provide specific information regarding technology protocols.

The **CIOB** includes a BIM protocol that sets out the protocol for collaborative design where independent models, with or without a model provided by the client, are required to be used. If the BIM protocol is not defined in the appendices of the contract, then the AIA Document E202-2008 BIM Information Modelling Protocol Exhibit or the latest edition is to be used. The design contributor responsible for each design element at each design stage and design level of development shall be as indicated in the table shown in section 1.1 and an additional table where all design elements are listed against the design contributor for each stage of development (conceptual design, design development, technical design, production information, as-built, and operation and management). The software to be used for the working schedule is to be specified as an appendix. Depending on the level of complexity and ability to handle a quantity of data, the software adapted for a BIM may also be capable of producing the time management data (CIOB, 2013a).

Clauses 3.5, 4.5 and 4.8 of the **AIA** BIM&DDE assign the architect (unless noted otherwise) as responsible for managing and maintaining the centralised electronic document management system (if in use) and protocols for transmission, use, storage and archiving the data, as well as for developing the BIM and model management protocols. All project participants are to review, revise and agree in writing to these protocols (AIA, 2013c).

Clauses 4.1-4.5 of the AIA BIM&DDE establish the extent to which the BIM protocol will be used: (i) just to fulfil obligations in the agreement but project participants will not rely upon the model unless agreed in writing or can do it at their sole risk; (ii) the parties will develop, share, use, and rely upon the model to the extent of the agreed model scope, authorised uses and LOD. The modelling protocol must address (AIA, 2013b):

(i) Identification of the model element author
(ii) Definition of the various LOD for model elements and associated authorised uses for each LOD
(iii) Identification of the required LOD of each model element for each milestone
(iv) Identification of the construction classification system to be used
(v) Processes for transmission and sharing
(vi) Processes by which participants will identify, coordinate and resolve changes to the model
(vii) Details regarding anticipated as-designed or as-constructed authorised uses for the model
(viii) Anticipated authorised uses following completion of the project
(ix) Other topics

Additionally, clause 4.6 of the AIA BIM&DDE requires the parties to include a copy of the latest version of the digital data protocol in the model so that it is accessible to the project participants (AIA, 2013b).

Clauses 4.8.2-4.8.3 of the BIM&DDE and clause 1.7 of the BIM-PF (points 1-8) establish that the model management protocol should include (AIA, 2013b; AIA, 2013c):

(i) Model origin point, coordinated system, precision, file formats and units
(ii) Model file storage location(s)

(iii) Processes for transferring and access model files
(iv) Naming conventions
(v) Processes for aggregating model files from varying software platforms
(vi) Model access rights
(vii) Identification of design coordination and clash detection procedures
(viii) Model security requirements
(ix) Responsibilities of the model manager (architect unless noted otherwise) to:
    a. Collect incoming models (coordinate submission and exchange of models; create and maintain a log of models received; review model files for consistency; and maintain a record copy of each model file received.
    b. Aggregate model files and make them available for authorised uses
    c. Maintain model archives and backups consistent with the archive requirements
    d. Manage model access rights
(x) Other

Clauses 1.1, 1.2 and 1.4 of the AIA BIM-PF establish the responsible participants for the implementation of the BIM protocol, the data that comprises the model and the technical requirements for the utilisation of the BIM (AIA, 2013c).

The **AEC (UK)** BIM protocol provides a series of recommendations for the management of incoming CAD/BIM data, such as: modifications should be kept to a minimum unless the received data format prevents design processes, in which case the coordinator must provide approval for the modification of the incoming data, CAD data might need to be shifted to 0,0,0 before importing, details of the changes made during the 'cleansing' of the data must be documented in the Project BIM Execution Plan, and the ownership of this 'cleansed' data is transferred from the originator to the 'cleansing discipline' which is then stored with the WIP data unless deemed appropriate to be shared (Coombes, et al., 2012).

The AEC (UK) also recommends the use of a 'Model Development Methodology' during the early stages to enable rapid model development with low hardware requirements. The elements can be classified or graded in four categories: G0 – schematic, symbolic place holder, particularly relevant to electrical symbols which may never exist as a 3D object; G1 – concept, simple place holder, minimum level of detail, superficial representation; G2 – Defined, contains relevant metadata and technical information, sufficiently modelled to identify type and component materials, at least a 2D level of detail suitable for the "preferred" scale, sufficient for most projects; and G3 – Rendered, as G2 but in 3D representation. The BIM protocol recommends an accuracy of approximately 1:50 for the 3D modelling. The protocol also provides recommendation about the spatial location and coordination systems, units and measures (Coombes, et al., 2012).

The **NATSPEC** guide recommends the use of available open standards to be specified in the BIM Management Plan and the use of the most current version of IFC Model View Definition formats[15] and ASTM E57 3D file format[16]. Additionally, this guide recommends that the BMP should address among other: strategy for hosting, transferring and accessing data between technical disciplines;

[15] http://www.standard.no/Global/PDF/ISO-TC59-SC13/N_287_Integrated_IDM-MVD_Process_for_IFC-formats.pdf (also used by Trafikverket in Sweden).

[16] http://www.ri.cmu.edu/publication_view.html?pub_id=6767

methods for showing major equipment space clearance reservation for operations as well as for showing functionality and circulation paths for the delivery, supply, processing and storage of material; proposed BIM software to be used by each discipline; strategy to import/export data; file formats for file submission and exchange; and file exchange protocol (NATSPEC, 2011).

The guide also includes a series of technical recommendations related to the selection of the software, equipment coding, metadata, points of reference, modelling geographical location, and additional modelling standards (NATSPEC, 2011).

8.3.9. Information Management

The construction team and the client discuss during the 'Pre-Start Conference' in stage 2 of **QTMR**'s ECI and later report in the outputs from the partnering workshops: lines of communication between parties, submission and access to project records, post construction review and any other issues deemed relevant. Permission to use must be granted for detailed design before construction documentation can be developed, and later for construction documentation to be used (QTMR, 2009f).

For QTMR's D&C, it is recommended that a stage verification process for the design review to monitor the design process is established so the client can have a clear idea of the design end product and give feedback when needed. Normally, 85% design development is deemed suitable to assign 'Permission to Use'[17] (QTMR, 2011).

Section 8.2 of **NSW RMS'** ECI deed specifies that design documentation includes models and digital records, in computer readable and written form, or stored by any other means, required for the performance of the tenderer's obligations or which the tenderer or any other person creates in relation to this document or the RFT (including the design of temporary works), and includes the Tender Design (NSW RMS, 2013d).

NSW RMS' D&C deed establishes that the Project Verifier can insert 'Hold Points' or 'Witness Points' in the project plans (NSW RMS, 2013b), and must review, comment on and monitor the design performance as well as verify final versions of design documentation (NSW RMS, 2013a). The levels of development of the design documentation are defined in terms of: developed concept design, preliminary detailed design, substantial detailed design and final design documentation states. Within which, the contractor is required to deliver 4 -2 sets of all documents to the different relevant parties and a written report. The design must also be delivered in digital form as per the Scope of Works and Technical Criteria. Additionally, where subcontractors have been involved in the development of the design, they must sign a document in the form of schedule 26 (NSW RMS, 2013b).

MRWA's contract states that the contractor must provide five copies of draft reports to the Project Review Group prior to each monthly meeting. A copy of all records relating to the project should be kept in Perth and retained there for five years from the expiry of the last defects correction period. Additionally MRWA can request copies of any records about the project.

[17] *Innovative or unique designs may lead to maintenance problems in future years unless such details are considered by the Principal during the tender phase and during design development* (QTMR, 2011).

The Design Verifier must verify at each 15% and 85% stage of completion in relation to: *(i) geometric road design for urban / rural roads; (ii) structural design; (iii) geotechnical, pavement and bituminous surfacing design; (iv) electrical design (including traffic control signalling and lighting); (v) waterways and drainage design; and (vi) ITS design.* The final design version (100%) is to be verified regarding constructability, quality, and compliance with the SWTC. This must be reflected through a report for each final version. As in NSW RMS, the verifier is independent from the contractor, consultants and subcontractors (MRWA, 2014).

The **CIOB** contract establishes that the Design Coordination Manager shall provide the attendants with a current copy of the database of submittals in native format, in accordance with the File Transfer Protocol, for the progress meetings (CIOB, 2013b).

When using BIM, unless so authorised, the contractor may not modify, transmit or use any model provided by the client for any purpose, except in connection with the works and consistently with the levels of development indicated in a table which defines the levels of development, design and uses. This table defines each level of development in terms of the design stage (including preparation for tender), geometry, content, analysis, cost control, time control, licensing and approvals, construction and other uses (see section 1.1). When the contractor is required to make a contribution to the model the contractor retains the copyrights over this contribution and any information derived from it, subject to the client's right to use the design contribution. In this case the contractor is required to maintain and update the contribution throughout the course of the works (CIOB, 2013a).

If the contractor is to design the whole of the works, it shall provide a Common Data Environment and/or File Transfer Protocol (protocol for uploading, downloading, managing access to, security of and transferring digital files by electronic means) (CIOB, 2013a).

A Common Data Environment is a web-based server enabling multiple users to collaborate in managing digital information in accordance with an agreed protocol. In case the data is not automatically maintained in the common data environment, the project time manager[18] shall archive each submittal of the working schedule and/or planning method with a unique file name (including the data date) and shall make and maintain a database of submittals (which includes 14 fields such as identity of the party making the submittal, date, nature, and name of the submittal, file name and location, size, number of activities, status (accepted, rejected or conditional), and all information related to the decision) (CIOB, 2013a).

The CIOB contract also offers a list of standard data fields which includes the nomenclature to be used to describe users based on their role as contributor (e.g. Civil Design Contributor - DCC01) and other key elements such as milestones (MS), levels (LV), etc. The purposed of this is two-fold: (i) to provide a minimum necessary categorisation of data to permit filtering, retrieval and sorting of data for analysis and management reporting during the course of the works; (ii) provide a structure for benchmarking and comparative analysis of data between projects (CIOB, 2013a).

Ideally, all correspondence and other information flow should be managed by a document management system (DMS). This system should be capable of making sure that parties who are required to see documents actually get them and respond. If ordinary email is used instead, the

[18] The project time manager is engaged as a consultant by the client but works independently and fairly, failing to do so is at the client's risk.

codes should be used in the subject and all emails are deemed to have been received when sent, provided that the stated subject code is used in the transmittal. Additionally, the CIOB contract requires the working schedule, planning method statement, contractor's statement of construction methods and any client provided models or other models, and subcontractor's data to be made available, transparently, in native format to the contract administrator and listed persons (CIOB, 2013a).

Clause 3.4 of the **AIA** BIM&DDE establishes that only data received after there is agreement and documentation of the digital data protocol can be used, and only within the authorised uses identified in the protocol (AIA, 2013b). Clause 3.5 clarifies whether the parties intend to use a centralised electronic document management system or not. If it is to be used and unless noted otherwise, the architect is responsible for managing and maintaining the system as well as facilitate the establishment of protocols for transmission, use, storage, and archiving the data in consistence with the approved management protocol (AIA, 2013b). However, a different participant can be identified for the implementation of the digital data protocol through the Project Digital Data Protocol Form (AIA, 2013e). This document also establishes the requirements for: (i) a centralised electronic document management system (if chosen); (ii) training and other ongoing and start-up requirements with respect to the use or management of digital data; (iii) procedures and requirements for storing digital data during the project and archiving; and (iv) data formats, transmission methods and authorised uses from project agreements and modifications to closeout documents (AIA, 2013e).

The **AEC (UK)** establishes that models should be sub-divided between disciplines and within single disciplines to avoid file sizes becoming too big or slow to operate. What is to be modelled and to what level of detail and/or development should be clearly documented (Coombes, et al., 2012).

The AEC (UK) BIM protocol, as the CIOB contract, recommends the use of a Common Data Environment to share project information among all team members. The use of such approach requires data to be dealt with in four areas:

(i) Work in Progress (WIP): has not been checked or verified, these files are developed in isolation and each stakeholder is responsible for the information they input, they are stored and worked on from the "team's WIP section of the filing system and can be organised by discipline);

(ii) Shared: design data which has been checked[19], verified and approved, made available for project-wide formal access through an exchange protocol or shared repository. As soon as the data is approved after validation it should be made available so every member is using the latest version which is issued in conjunction with verified 2D drawings to minimise the risk of communication errors. This data can include externally produced data that is to be shared across the project (e.g. environmental information, safety standards, etc);

(iii) Published: 2D electronic drawings, exported data, project documentation. The information available in this section has been subject to the Document Control System established for the project for revision/issue control. If relevant, both soft and hard

[19] AEC (UK) provides BIM Protocol Model Validation Checklists for Autodesk Revit and Bentley ECOsim Building Designer and Graphisoft ArchiCAD for Export. The general recommendations for the publication checklist can be found in Appendix 3

copies can be kept of issued deliverables (all BIM files and associated data should be kept in the WIP section until it is exported into non-editable formats).

(iv) Archive: all approved output data from the BIM; this includes published, superseded and "as-built" drawings and data, key stages of design process, completed version of the model, exported data and associated drawings. The nomenclature should follow easy logical rules (P.32 provides an example of these rules).

For large or complex projects, it might be advisable to divide the model into 'zones' or 'packages of work'[20], in which case a model matrix should be developed to document the file structure (Coombes, et al., 2012). AEC (UK) also provides a template for such matrix (AEC (UK), 2012a). The coordinator must assess and verify minimum quality compliance before submitting new objects to the corporate library (Coombes, et al., 2012).

NATSPEC requires that copies of all approved submittals and other documents normally provided in traditional paper-based formats should be provided in PDF format. External documentation should also be made available in PDF format, either by conversion from the original format or scanning of the physical copies (NATSPEC, 2011).

8.3.10. Information Hand-over/As-built Documentation

QTMR's C683 General Conditions Contract Guide establishes that if the contractor is required to supply any documentation in the contract agreement, the contractor shall provide the number of copies established in the contract (or 5 if not specified) and the client will own the documents hence forth but only be able to use them or copy them for the use, maintenance or alteration of the works (QTMR, 2005). QTMR's ECI contract further specifies that, on project practical completion, the contractor provides the as-built drawings, specifications and all certifications to the client so the designer can certify the works have been constructed in accordance with the contract. The client then retains complete ownership of the intellectual property rights of the design and is able to take the project works to the market as a construct-only contract to obtain a new contractor. The terminated contractor is not invited to tender (QTMR, 2009e). The D&C deed requires all project related material to be handled in accordance with OnQ (Generic Methodology – Concept Phase). Additionally, to achieve 'Practical Completion' the contractor must: hand-over three sets of as-built drawings and specifications; copies of all investigative reports carried out by any of the parties in connection with the contract; and any relevant data for QTMR's Road Management Information System (ARMIS), among other (QTMR, 2011).

Sections 5.1 (a) and (b) of **NSW RMS'** ECI give ownership of, all intellectual rights in, and irrevocable license to use the design documentation to RMS when each item comes into existence. Where design documentation is defined to include: design standards, design reports, durability reports, specifications, models, samples, calculations, drawings, shop drawings, digital records and all other relevant data; in a computer readable and written form, or stored in any other means. Section 5.1 (c) provides perpetual, irrevocable, royalty-free licence to use (including to sub-licence) any computer software (including both source code and object code versions). The ECI Tenderer has an irrevocable

[20] The AEC (UK) BIM Protocol, pages 21-23 offer general principles for the segregation of data in large/complex projects.

licence to use the Design Documentation for the performance of its obligations under this document and in respect of the RFT (NSW RMS, 2013d).

The project verifier involved in NSW RMS' D&C must acknowledge that the other parties are entitled to and will rely on any certificate or other document signed or given by the project verifier under or pursuant to this deed or the project documents (NSW RMS, 2013a). The final design documentation must be verified through signed documentation from the project verifier and the contractor, and where relevant from the subcontractor, proof engineer and local road works authorities (NSW RMS, 2013b). This contract presents similar clauses to the ECI in relation to the ownership of intellectual property rights and licensing.

The design documentation requirements are described in the SWTC. The contractor must provide all data, inputs, calculations and outputs in electronic form that enables interrogation, manipulation, and re-calculation by RMS representatives, the project verifier, and where relevant, the proof engineer. The design must be in electronic form as specified in the scope of works and technical criteria. The contractor must submit the final design documentation on a progressive basis at a reasonable rate of submission. The contractor must give RMS four sets and one copy in electronic format of survey of works as executed and work as executed design documentation in accordance with the requirements of the scope of works and technical criteria (NSW RMS, 2013b).

In **MRWA**'s D&C, *Design Documentation means all design documentation (including specifications, models, calculations, material test results, drawings and Design Verifier's models, calculations and reports at 15%, 85% and final stages), that the Contractor or any other person creates in respect of the Project (including the design of temporary works), whether in computer readable, written or any other form.* At the completion stages 15% and 85% of each discrete project design element, the contractor must provide MRWA three copies of the draft documentation for review and comments. The contractor must use only final versions for construction purposes and provide three copies of all final versions to MRWA, including amendments. Final drawings are provided to MRWA through a set of four copies, as well as surveys and as-constructed information (MRWA, 2014).

The Working Schedule and Planning Method Statement are core documents of the **CIOB** contract upon which any post-contract design contribution and the production of the works on site are to be managed and controlled. Nothing is required by this contract to be submitted and delivered in hard copy alone, and all management information required to be accepted or approved is to be transparently made available to the contract administrator and the listed persons (CIOB, 2013b).

Clause 4.9 of the **AIA** BIM&DDE establishes the services associated with providing post-construction model use and the responsible participants (AIA, 2013b).

According to the AEC (UK) protocol, where drawings are a product of the BIM, traditional drawing conventions still apply (i.e. to maximise efficiency, a policy of minimum detailing without compromising quality and integrity shall be adopted and repetition of details should be eliminated; avoidance of view duplication is essential to ensure drawings maintain their integrity as the iterative design process progresses and amendments are made, etc) (Coombes, et al., 2012).

The BIM data must be prepared, checked and exchanged taking into account the requirements of any recipient software application (e.g. link to analysis packages or interface with GIS). Before transferring the data to a different software platform: the development team must understand the requirements and limitations of the target software/hardware system; 2D outputs from BIM must be

useful to the team, reasonably complying with the project CAD standards, and allow easy manipulation of the data held within the file (e.g. layering); the data exchange protocol must be verified with a sample testing to ensure the data integrity is maintained; and the team must use export layer tables during the export to CAD (Coombes, et al., 2012).

Upon Practical Completion following the NATSPEC guide, BIM files are to be summated to the client, and cleaned of extraneous 'scrap' or 'working space' layers, abandoned designs, object creation and testing places, empty layers, and other content not required for future asset management. The client shall receive the following: 3D Geometric Deliverables – Construction Coordination Model - The contractor shall be responsible for providing the client consolidated as-built Model(s). These files should be delivered in native file formats and IFC file format; 3D Geometric Deliverables – Design Intent Model - The Design Team is to ensure that the Design Intent Model remains current with all approved bulletins for overall scope both in native and IFC file formats. As-built drawings are also to be delivered in PDF format with fully bookmarked pages and the design intent model should be delivered both in PDF format and in DWG format. All digital deliverables are to be submitted on DVD/CD with the data clearly organised and software version(s) labelled (NATSPEC, 2011).

8.3.11. Information Security/Confidentiality

The **QTMR** documents studied do not address this issue.

NSW RMS' D&C deed, all information relating to the contractor's work and any discussions related to the deed must be maintained secret and confidential, and the contractor may disclose it only to those persons to whom disclosure is reasonably necessary for the purpose of the contract. Exceptions apply to data which is normally accessible by the public or required to be disclosed by law (NSW RMS, 2013b).

In **MRWA**, all information about the project, including the discussions and negotiations leading to the deed are to be considered confidential. Additionally, Intellectual Property Rights include *rights in relation to confidential information, trade secrets* (MRWA, 2014).

The model provided by the client under the **CIOB** contract is maintained in accordance with the BIM Protocol under the direction of the Data Security Manager. This is a person identified as such in the contract agreement or such other person appointed by the client, or if none is appointed, the contract administrator. The data security manager is responsible for managing the common data environment, file transfer protocol and the privileges of input, upload, download, access, and editing of any data provided electronically for use during the contract and in particular any BIM protocol. However, none of the documents provided or contributed by the contractor are to be used by them or the client for any purpose other than carrying out the works, and the determination of rights and liabilities of any party arising under, or in connection with the contract or connected contracts. Exceptions apply to: (i) information published in the progress reports; (ii) cases in which disclosure of information to the employees of the contractor or the client and their professional advisers is needed; (iii) if information has been made available to the public; (iv) for publication of an award; or (v) disclosure is needed for dispute resolution. This confidentiality clause expires three years after the termination date of substantial completion date, or if the data is no longer consider sensitive (CIOB, 2013a).

Clause 1.2.1 of the **AIA** BIM&DDE provides all the project participants with the ability to enforce the obligations to apply the digital data and BIM protocols in all subsequent contractual agreements for

the project (subcontractors and consultants) against all other project participants, thus, protecting against failure to downstream the protocols (AIA, 2013f). Clause 1.4 defines confidential information as anything clearly marked confidential and clause 2.2 allows parties to release this information only for the use of participants that work exclusively for the project and are subject to the agreement or if forced by law (AIA, 2013b). Finally, the Digital Data Licensing Agreement grants license to the receiving party from the transmitting party to use the data solely and exclusively to perform services for, or construction of, the project, and clause 2.4 establishes that the transmitting party retains all rights over the data, not granting any of those rights to the receiving party (AIA, 2013d).

AEC (UK) strongly recommends that all BIM project data resides on network servers subject to regular back-ups and that staff access to BIM project data held on the network servers is done only through controlled access permissions (Coombes, et al., 2012).

NATSPEC recommends that design teams shall establish a data security protocol to prevent any possible data corruption, virus 'infections' and data misuse or deliberate damage by their own employees or outside sources. Both the Design Team and Construction Teams shall establish adequate user access rights to prevent data loss or damage during file exchange, maintenance, and archiving (NATSPEC, 2011).

8.3.12. Contract Model

QTMR's ECI is described as a negotiated D&C contract where the contractor is chosen through a two-stage process (see Figure 3) (QTMR, 2013a), although stage 2 can be amended to a construct only contract (QTMR, 2009c). This model uses a single contract to cover both stages, where both the contractor and designer's acceptance of the stage 2 offer can be done independently of each other. During the first stage the contractor works under a service agreement to develop, with the designer and the client, the design to a point where it can by accurately priced. The second stage offer can be based on either RAP or RAMP (QTMR, 2009c). The main contract used is supported by the General Conditions of Contract and Schedule (QTMR, 2009c). Partnering is a contractual requirement to facilitate good working relationships between participants (QTMR, 2009b).

QTMR's D&C contract is not based on Australian Standard General Conditions of Contract for Design and Construct Contracts (QTMR, 2013b). Relationship contracts used in D&Cs need to be defined in terms of how teams work together to deliver the contract in accordance with the specifications and Brief. These contracts should be clear in that relationships should be used to deliver the contract in line with contract requirements and not as means to alter the contract (QTMR, 2011).

In **NSW RMS**, the contract is made solely of the contract documents: GC21 General Conditions of contract, contract information, annexed schedules, principal's documents at the date of contract, and the other contract documents listed in the contract information (NSW RMS, 2013c).

NSW RMS' ECI tenderer must acknowledges and agree, without limiting the terms of the RFT, that the role contemplated for RMS in respect of the preparation of tenders by the ECI tenderer and the other ECI tenderer is as described in the RFT. Nothing in this document will be construed or interpreted as constituting the relationship between RMS on one hand and the ECI tenderer on the other hand as that of partners, joint venturers or any other fiduciary relationship. The obligations of the ECI tenderer, if more than one person, under this document, are joint and several and each person constituting the ECI tenderer acknowledges and agrees that it will be causally responsible for

the acts and omissions (including breaches of this document) of the other as if those acts or omissions were its own (NSW RMS, 2013d).

Under NSW RMS' D&C contract, the contractor is responsible for the design development and documentation, as well as the construction of the works. Neither RMS nor RMS representatives are responsible for carrying out the works or the design documentation (NSW RMS, 2013b).

Similarly, under **MRWA**'s D&C, to the extent allowed by law and unless provided otherwise by the contract, the contractor is solely responsible for all aspects of the planning, control, supervision and management of all the work under the contract. The design documentation is to be developed and completed in accordance with the deed and otherwise to *accepted industry standards* (MRWA, 2014).

The **CIOB** contract was designed to meet the needs of different contract models, including: construct only, D&C, ECIs and Alliances, using traditional drawings or BIM. Therefore, the language use is rich in generic terminology such as 'the works', 'design contribution' (any design or part of the design, data or information which is created or prepared by the contractor, subcontractor, listed person or connected party, that is communicated to, or shared with any other design contributor in any way), etc. However, it states that the contract requires a collaborative approach to the management of design, quality, time and cost. Under this contract, the special conditions take priority over the contract and are project-specific contract documents which identify any changes to the terms of the standard conditions of contract, whether by addition, deletion or amendment. Examples of matters referred to in the contract that are to be defined in the special conditions are: explanation of the status of a reference design; particular persons to be identified as design users; level of development of each model and/or federal model prepared by or under the direction of the client; ownership and licensing of the model and/or federal model; insurance required to be taken by the client and/or contractor; rules of calculating prices and cost of the works; etc (CIOB, 2013a).

Where the client provided model is prepared as a contract document or the contractor is required to design the whole of the works using BIM, the quantities of materials are to be extracted from the model and no separate bill of quantities is required (CIOB, 2013a).

The **AIA** Integrated Project Delivery Guide discusses the potential challenges and benefits of adapting contract models such as: Multi-Prime agreements, Design-Build, Design-Bid-Build, Construction Manager – Constructor (CMc), and Construction Manager – Adviser (CMa), as well as the possibility to use Multi-Party Agreements (MPA) through Alliance contracts, Single Purpose Entities (SPE) or Relational Contracts (see schematisation in section 8.2). The best argument is provided for the CMc as it is particularly well suited for IPD. The recommendation to use Alliance, SPEs or Relational Contracts depends on the specific characteristics of the project (AIA, 2007). The AIA GIC-DPD also provides potential modifications to AIA developed contract models such as B101–2007, to allow the use of digital data and BIM documentation (AIA, 2013f)

The **AEC (UK)** documentation does not provide guidance as to the contract model.

The contract drafted following **NATSPEC**'s guidelines should properly define the duties of the parties before BIM modelling begins. The BMP then defines the contract model to be used (Design-bid-

build, D&C, ECI, etc) and legal status of the BIM for the design stage and after contract award for the constructions stage (e.g. binding[21], informational, reference, reuse, etc) (NATSPEC, 2011).

8.3.13. Compensation

Clause 40.2 of **QTMR**'s General Conditions of Contract states that the client must pay the contractor if required to advise whether a proposed variation can be effected (QTMR, 2005).

Under **QTMR**'s ECI, the contractor and designer are compensated for their services in stage 1 through reimbursement of the time of its personnel (contractor) and rates submitted in the tender (designer). Although this sum might be capped following tender negotiations (QTMR, 2009d). The ECI offers the possibility to pay the contractor a 'Design Savings Bonus' for stage 1 if the total contract price submitted as part of the stage 2 Offer is less than the Main Roads Project Works Budget. This bonus is calculated as a predetermined percentage of that difference. For Stage 2, this contract offers the possibility of using a RAMP, with savings shared on components of the Stage 2 documentation and construction of the works. This can be achieved by including a schedule to the General Conditions of Contract provisions that only comes into effect if the parties agree (QTMR, 2009c; QTMR, 2009e). Under this agreement the contractor is paid its actual cost plus an agreed amount for profit and overheads. Additionally, the maximum price is a limit to the amount payable by the client for the relevant work or item, and the client and the contractor may share in the savings where less than the 'Maximum Price' is spent.

The RAP is developed based on a benchmark of a minimum of three past projects tendered competitively, which are then analysed by the independent estimator. The RAP is normally determined once 70% of the design has been developed, 30% of the detailing completed and based on an *open books*[22] approach. It is paid either as a lump sum, scheduled rates with provisional sums or a combination of both (QTMR, 2009e).

In case the most attractive solution found during a QTMR D&C tender is a combination of proposals from competing tenderers, the tender documents should contain provisions to allow the use or purchase of intellectual property contained in each tender. An Offer Contribution Amount is one such approach. However, this approach might require negotiating with the tenderers in which case the Probity Advisor must be involved in the negotiations**.** The client may also consider offsetting tender preparation costs by making a financial contribution to tenderers due to the high investment often associated to D&C tender preparation. The 'Offer Contribution Amount' depends on several factors such as the cost of the contract, complexity of the design and the necessity to undertake further studies. In this contract the client enters an agreement with one contractor, who undertakes both the design and the construction of the works for a lump sum (QTMR, 2011).

According to **NSW RMS'** General Conditions of Contract, if the client instructs the contractor to use a particular method without first agreeing in writing with the contractor the effects of the instruction, the contractor may claim an increase in the contract price to be valued according to clause 47, unless the change of instruction arises from the contractor' act or omission. Additionally, the

[21] Imposing a legal (contractual) obligation between the author/s and recipient/s. Used in this context to mean a Design Model that represents what has to be constructed under the terms of the contract.

[22] *The Contractor will share all information and documentation of the financial costs of performing the work under the Contract on a transparent and full disclosure basis* (QTMR, 2009c).

contract information may stipulate that the contract price includes a provisional sum for works that are only to be carried out under client's instructions (NSW RMS, 2013c).

NSW RMS' ECI model stipulates that if RMS decides to enter into a Project Deed with the Other Tenderer, then RMS must pay the ECI tenderer a pre-agreed amount for participating in the first stage of the ECI (NSW RMS, 2013d).

NSW RMS' D&C Deed Contract information establishes that RMS pays their contractors for progressively completing milestones determined on a monthly basis based on the value of work carried out. These payments are made for each discrete design element of the contractor's Work and are defined as percentages of the total value of the discrete design element at the: (i) developed concept design stage; (ii) preliminary detailed design stage; (iii) substantially detailed design stage; and (iv) final design documentation stage (NSW RMS, 2013a). In addition to the project contract sum, the contractor may be entitled to be paid the incentive amount, if it can provide a written statement detailing the level of achievement of the 'Key Result Areas' against the key performance indicators, and all relevant supporting information including all data relied on to calculate the contractor's performance (NSW RMS, 2013b).

Compensation is mostly discussed in the **MRWA** documentation, in terms of the payment schedule established in the deed. Under this contract, the contractor *grants to Main Roads, and will procure that all owners of any such Intellectual Property grant to Main Roads, a perpetual, royalty-free, non-exclusive licence (including the right to sub-license and disclose to any Third Party)* to use any Intellectual Property in the project documentation *for the purpose of commissioning, designing, constructing, testing, using, repairing, maintaining, upgrading, developing or modifying the Project Works or otherwise in connection with the Project or the Site.* In exchange, MRWA grants *royalty-free, non-exclusive licence (including the right to sub-license) to use any Intellectual Property owned by or licensed to Main Roads for the purposes of the Project only,* to the extent necessary for the project. Any cost savings arising from the changes proposed by the contractor are to be divided equally between MRWA and the contractor (MRWA, 2014).

In the **CIOB** contract, compensation is also discussed in broad terms related to the current value, penultimate value and final value of the works. There is no specific mention about compensation due to the work involved in the development of the model or early involvement of the contractors. However, the contract mentions that any value engineering or suggestion by the contractor as to how the works may be made more cost-effective, is deemed to be a contractor's design contribution (CIOB, 2013b).

Article 4 of the **AIA** Digital Data Licensing Agreement states whether there will be a fee or other type of compensation associated to the transmission and use of the digital data (AIA, 2013d).

Neither **AEC (UK)** nor **NATSPEC** issued recommendations related to compensation.

8.3.14. Risk/Insurance

QTMR's Principal Arranged Insurance (PAI) is available for contracts between AUD1 million and AUD100 million and is built around each individual contract, not projects. For contracts between AUD100 million and AUD250 million, Main Roads can extend the value limit by negotiation with the insurers to cover the additional risk. For contracts over AUD250 million, Main Roads negotiates with the insurers using the standard PAI cover as a starting point. PAI is under two separate policies: (i)

Material Damage; and (ii) Public and Product Liability. Standard contract insurance requirements include: the works, professional indemnity, public liability, product liability, worker's compensation, plant and equipment insurance, and vehicle insurance (QTMR, 2009b).

During stage 1 of QTMR's ECI, the contractor must reach an agreement with the client on the 'Risk Register' and include it in the 'Detailed Planning and Preliminary Design Report'. The General Conditions of Contract also usually include clauses setting down the contract requirements for the insurance policies to be provided by the Contractor with respect to each of the classes of risk. The four associated policies are generally known as 'Insurance of the Works', 'Professional Indemnity Insurance', 'Public Liability Insurance' and 'Employer's Liability Insurance' (QTMR, 2009e). During stage 2, the client is responsible for effecting the required insurance policies for the works (QTMR, 2009f). Under this contract type, the designer is required to provide insurance against adequacy of design, suitability for the site and so on for the Stage 2 final design, the client accepts the risk of delays and associated costs in the preliminary design phase, and the contractor accepts the risk of delays and associated costs in the final design phase. Additional options exist in documents for either the client or contractor to arrange insurances but PAI is usually chosen along the general lines of RCC contracts (QTMR, 2009b).

Under QTMR's D&C, the contractor and designer must take out 'Professional Indemnity Insurance', 'Worker's Compensation Insurance' and 'Public Liability Insurance'. Values should be as shown in the Annexure Part A, General Conditions of Contract (subject to PAI requirements). QTMR has implemented a Principal Arranged Insurance (PAI) scheme, under which a bulk policy covers contracts to a value of AUD150 million for works and liability and the project specific insurance uses the bulk policy as a basis but also adds PI insurance. If the PAI scheme is not suitable, project specific insurance requirements are negotiated, where the upper limits, premiums and deductibles for this type of cover depend on the value and risk profile of the project (QTMR, 2011).

Similarly, **NSW RMS** General Conditions establish that the client effects an insurance policy or policies to cover the client, the contractor and subcontractors employed from time to time in relation to the works for their respective rights, interest and liabilities with respect to material damage to the contract works and third party liability. Additionally, the contractor must have in place insurance for the minimum amounts specified in the contract information, including: workers' compensation, professional indemnity insurance (if required by contract) and motor vehicle/plant insurance or third party property damage insurance. The contractor must ensure that the subcontractors, suppliers and consultants are insured at all times for workers compensation and related liability (NSW RMS, 2013c).

The D&C deed further stipulates the involvement of a project verifier who is to monitor, verify and audit the design and construction documentation and works. The project verifier's representative for the design verification services must possess a recognised qualification relevant to the position and the services and have at least five years of experience in the design project verification of large projects similar to the project works, temporary works and contractor's work and at least 20 years of experience in the design of major road projects. This is done to reduce risk (NSW RMS, 2013a).

The project verifier needs a professional indemnity insurance for AUD10 million covering the appointment of the project verifier plus 6 years following the date of final completion (or the date of termination of the deed of appointment of project verifier whichever is earlier). The insurance can be taken out as annual covers where the cover is to include a retroactive date being the date of the

project deed. The contractor is responsible for any excess payable under the principal-arranged insurance (AUD50,000 for product liability and AUD10,000 for any other claims). Additionally, the deed requires a document controller/site administrative assistant (NSW RMS, 2013a).

RMS has effected an insurance policy or policies to cover the client, the contractor and all subcontractors with respect to: contractor works – material damage and third party liability, professional indemnity (only for RMS, although may include others) until the date of completion. While the contractor must have insurance against worker compensation and motor vehicle/mobile plant/third party property and that every subcontractor is insured at all times for workers compensation (NSW RMS, 2013b).

MRWA provides the *Main Roads' Controlled Insurance Program Policies ("MRCIP Policies"),* which is *constituted by the Contract Works Material Damage Insurance Policy ("CWMDI Policy"), Contract Works Liability Insurance Policy ("CWLI Policy") and Workers' Compensation Insurance Policy ("WCI Policy").* Additionally contractors are required to obtain insurance for Contractor's Plant & Equipment; Motor Vehicle Insurance; Professional Indemnity Insurance; and Goods in Transit (if relevant). This is also payment milestone 1.1 (MRWA, 2014).

Under the **CIOB** contract all parties are to take insurance for the risks addressed in the special conditions, define for each project. The contractor is liable for any expense, liability, loss, claim or proceedings arising in connection with the carrying out of the works from personal injury (unless it is due to actions or neglect by the client), injury or damage to property if it is caused by negligence, breach of local law, omission or default of the contractor and its dependants (CIOB, 2013b).

The risk register is to be updated by the contract administrator within 5 business days from receiving any early warnings issued by the contractor or 'listed person'. This is followed by a risk management meeting with the design coordination manager (if any), the contractor, the project time manager and any other person likely to be involved in the resolution of the risk. During this meeting, steps to avoid or reduce the likelihood of occurrence and likely effects are to be identified, followed by the issuing of instructions considered necessary. The risk register is then updated by the contract administrator with the new data date, revision of the identified risks, agreements made and instructions given. Additionally, the contract must acknowledge that post-completion design liability is notoriously difficult to predict and the employer might usefully consider requiring a single premium payment for the contractor's project-specific professional indemnity insurances (CIOB, 2013a). There are no default provisions for the insurances under the contract.

The **AIA** IPD guide only points out that, traditional insurance products may not be available for IPD arrangements or third-party claims for personal injury and property damage. Therefore, a more than customary interaction with surety and insurance markets might be needed (AIA, 2007).

The **AEC (UK)** highlights the importance of properly communicating and tracking ownership of elements through the project time-line (e.g. floors that may be created by the design team, but are then adopted by the structural team to form part of the load-bearing structure) to avoid the risk of conflict (Coombes, et al., 2012).

NATSPEC does not include recommendations regarding insurance.

8.3.15. Additional Remarks - Staffing/Education

The 10% Training Policy for **Queensland Government** Building and Construction Contracts requires all contractors to up-skill workers based on the Department of Education, Training and Arts Policy (administered by Construction Skills Queensland) and is applicable to all transport infrastructure construction contracts valued in excess of AUD500,000. However, for contracts valued over AUD100 million, more specific requirements have to be included (QTMR, 2009b).

For ECI contracts over AUD100 million there is a government requirement for a Skill Development Plan to be included in the contract plan (QTMR, 2009e).

Section E of **NSW RMS**' general contract information (Contractor required to implement an Enterprise Training Management Plan accepted by the Principal) is 'yes' by default (NSW RMS, 2013c).

A NSW RMS' D&C contract allows requiring the contractor to implement an enterprise training management plan accepted by the principal (NSW RMS, 2013c).

*The **WA Governments**' Building Local Industry Policy requires Industry Participation Plans to be prepared for Government funded projects or contracts with a total value in excess of $20 million or when the value of the capital equipment exceeds $1 million.* Project specific Industry Participation may be required if: (i) *significant new technology transfer may be developed in the project; and (ii) significant new or increased capabilities may be developed to enhance the skills of locally based staff.*

Clauses 1.5 of the **AIA** BIM-PF establish the parameters for any training or support program that will be implemented to any collaboration strategy or technical requirements (AIA, 2013c).

NATSPEC's guide highlights that it is the responsibility of all consultants and contractors to have or obtain, at their cost, the trained personnel, hardware, and software needed to successfully use BIM for the project (NATSPEC, 2011).