OSM Readiness Tool

Assessing Off-Site Manufacturing Capability and Capacity

Version 1.0

A Sustainable Built Environment
Project 2.2

National Research Centre (SBEnrc)
Industry Report

Sustainable
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Project Partners

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Synopsis

This *OSM Readiness Tool* presents three steps:
1. understanding the project environment
2. recording knowledge, experience and capacity
3. evaluation of OSM capability.

OSM adoption can be enhanced though planning and engagement with stakeholders; including everyone contributing to the building project. Ideally all interested parties will be involved with OSM from the project inception.

The OSM Readiness Tool is a mechanism to assist with gauging the availability of capability and capability sufficient for the project. It involves the systematic assembly of essential types of OSM knowledge, experience and capacity using a series of nineteen structured questions. Once entered onto provided spreadsheet templates, it becomes a database of information called the *OSM_KnowledgeBank* which can be used to evaluate and score available capability and capacity. Consideration of the opinions of all Project Team stakeholders will provide a more effective OSM project.

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OSM PROCUREMENT MODEL

The proposed OSM procurement model is a method for improving confidence in the use of OSM on building projects. The model uses an *OSM Readiness Tool* to assess project stakeholder OSM knowledge and experience to indicate capability and capacity appropriate to adopting OSM on a given project. Productivity improvement is currently a high priority in the construction industry to both the industry and its clients. One of the most commonly cited productivity improvement opportunities is that of offsite manufacture (OSM). This commonly sought method has so far failed to deliver the promised improvement, predominantly due to the failure of the industry to adopt OSM in a systematic and effective way. Prior research into OSM has identified barriers to implementation, however the industry needs solutions to assist implementation. This report focuses on OSM capacity and capability to enable a more productive industry.

Introduction

Various terms are used interchangeably for off-site production of building components. Four common terms are: off-site production, off-site fabrication, off-site construction (preassembly and prefabrication) and off-site manufacture (OSM).

This report uses the term OSM acknowledging that it is used to mean a number of different manufacturing processes. This term is used to describe construction activities that include the manufacture and assembly of buildings or parts of buildings at a location distant from the building plus subsequent installation at a construction site.

The literature analysing the OSM construction model is mainly concerned with barriers to uptake[1]. In Australia, OSM has been identified as a key driver for a more sustainable and productive construction industry[2] but industry adoption is not comprehensive. Internationally[3], OSM has been recognized as an effective procurement model for construction.

The most beneficial OSM procurement model should include everyone contributing to the building project involved as close to the Arranging the Project Team stage as possible[4].

Ideally all interested parties (the client, the project manager, the architect, the engineer consultants, OSM manufacturers, the construction manager, the builder, the sub-

1 Hampson, K.D. and Brandon, P. (2004) *Construction 2020—A vision for Australia's Property and Construction Industry*. CRC Construction Innovation, Brisbane.

2 Blismas, N. and Wakefield, R. (2009) Drivers, constraints and the future of off-site manufacture in Australia. *Construction Innovation: Information, Process, Management*, **9**(1), 72–83

3 Gibb, A. and Isack, F. (2003) Re-engineering through pre-assembly: client expectations and drivers. *Building Research & Information*, **31**(2), 146–60

4 Walker, D & Hampson, K. (eds.) (2003) *Procurement strategies: a relationship-based approach*, Blackwell Science Ltd., Oxford. .

contractors, and the OSM suppliers) are involved with the project from inception. Realistically, the membership of the Project Team will change over time, as the construction process progresses.

The OSM procurement model transforms AEC professional relationships by enabling shared OSM expertise at the start of a project. The conventional construction method Design-Bid-Build based on task expertise is replaced with a collective method of production that integrates design, procurement and construction through relationships. The competitive tendering model is replaced with a relationship-based project delivery strategy for increased project productivity based on identification and collection of essential OSM capability and capacity information.

Having both capability and capacity is necessary for effective implementation of the OSM procurement model.

OSM capacity: The maximum output level of OSM components that suppliers in the construction supply chain can potentially produce over a set period of time.

OSM capability: Possession of knowledge and skills that enable suppliers in the construction supply chain to produce OSM components which meet the project design and quality requirements, and comply to the specified standards.

The OSM model encourages early focus on building constructability by changing the location of production and the timing of supply chain involvement.

While OSM has significant advantages for construction projects, it is not suitable for every construction project. Gauging OSM capacity and capability will support the Project Team decision-making concerning the adoption of OSM.

Research reports indicating increased productivity resulting from using OSM focus on individual cases[5]. We take a more pragmatic approach by providing an *OSM Readiness Tool*. The tool has been developed with industry stakeholders to provide a systematic method for rating capacity and capability to facilitate an OSM procurement model.

OSM Procurement Timing

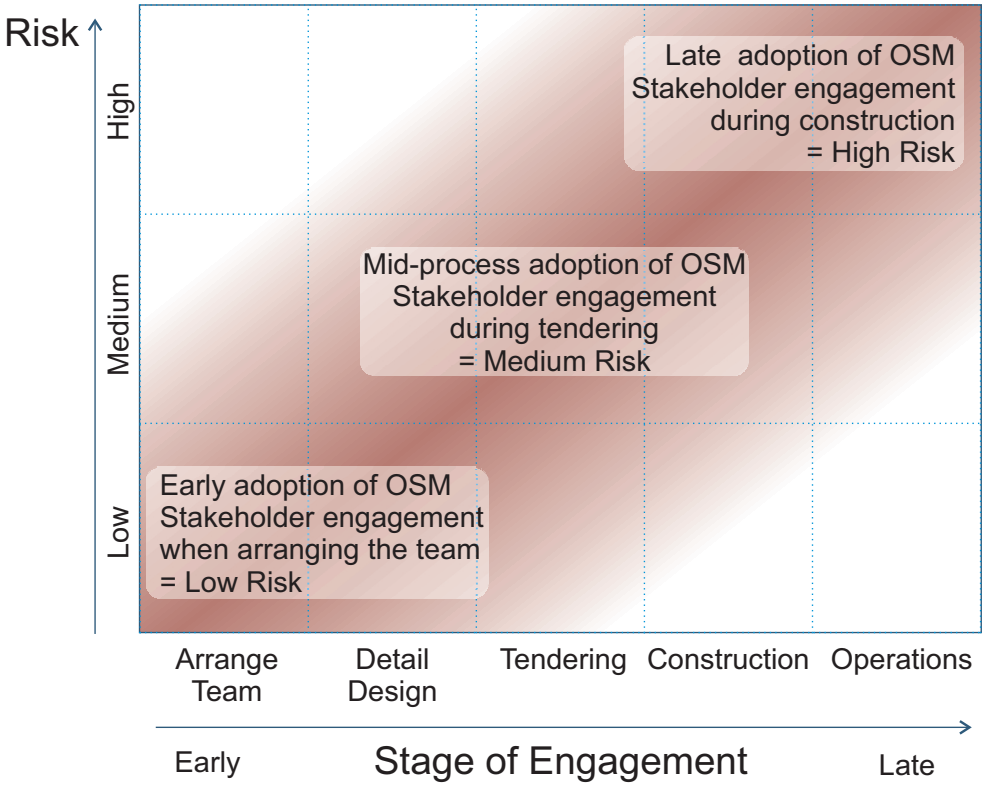
Successful OSM adoption can be increased though planning and engagement with all OSM stakeholders during the construction process. International studies indicate that benefits are accrued if OSM is considered at early stages and incorporated into the design[6].

The Risk Engagement Model (figure below) illustrates that the level of risk for successful project outcomes is related to the timing of OSM adoption decisions.

Early adoption of the OSM procurement model, with input from a wide variety of OSM stakeholders, is considered the low risk option. A high level of stakeholder engagement provides information concerning essential OSM capability

5 Baldwin, A.N., Shen, L.Y., Poon, C.S., Austin, S.A. and Wong, I. (2008) Modelling design information to evaluate pre-fabricated and pre-cast design solutions for reducing construction waste in high rise residential buildings. *Automation in Construction*, **17**, 333–41.

6 Blismas, N. (Ed) (2007) *Off-site Manufacture in Australia: Current State and Future Directions*, Cooperative Research Centre for Construction Innovation, Brisbane.



Risk Engagement model: Level of risk in relation to project stage of OSM stakeholder engagement

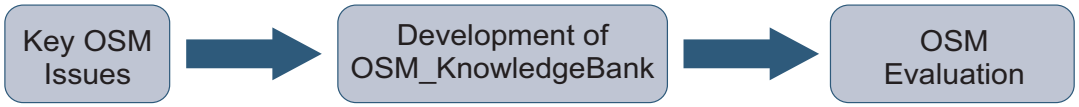
and capacity available for the project. Expertise, from a wide range of stakeholders, supports integration of OSM into the total project while forming the project team at the *Arrange Team* stage. The level of risk for the project can thus be considered low.

The impact of restricted OSM expertise in the Project Team or limited availability of required OSM capability and capacity at the *Tendering* stage of a building project, suggests a higher level of risk for project outcomes. Adopting OSM at this stage could mean additional delays for delivery and possible problems with integrating OSM specifications into the Shop Drawings indicating a medium level of risk. Adopting an OSM procurement strategy at the Tender stage can benefit a building project, but the benefits afforded by close AEC knowledge sharing relationships will be limited, thus constraining the effectiveness of an OSM procurement model.

Adopting OSM at the *Construction* stage of a project is always an option. However, the lack of initial OSM expertise at the *Detail Design* will mean a higher level of risk for timely project completion. The lack of early project team planning and engagement will certainly mean delays and difficulty with on-site installation. Thus, late adoption of an OSM procurement model could be considered a high risk delivery strategy. While BIM models may be prepared once the building has been constructed, the potential benefits from OSM are lost.

THREE–STEP OSM READINESS TOOL

The proposed *OSM Readiness Tool* includes a method for evaluating the capacity and readiness of the project stakeholders, in order to facilitate OSM procurement. There are three steps to the OSM Readiness Tool: understanding the project environment, recording knowledge, experience and capacity which enables the evaluation of OSM capability. The aim of the three steps is to inform the decision to use OSM as a procurement methodology for the project.



Introduction

The *OSM Readiness Tool* consist of three steps that overall provide an indicator of project and project team OSM capability and capacity.

Step 1

Step 1 discusses 4 environmental factors that influence decision making and the OSM delivery strategy at the project feasibility stage:

- Risk
- Knowledge Management
- Design
- Procurement

Step 1—Environmental issues

Step 2

Step 2 provides a mechanism for building a Project Team by systematically assembling essential types of OSM knowledge, experience and capacity. A tool has been developed using spreadsheets that can form a database of OSM information. This is called the *OSM_KnowledgeBank.*

A series of nineteen structured questions are group according to the Stage 1 environmental factors. The questions are asked of project participants involved with OSM information (eg. designers), management (eg suppliers) or responsibility (eg project managers).

The database is intended to be dynamic and it is expected that your OSM_KnowledgeBank will continue to grow as more participants engage in OSM projects. The Evaluation Tool can also signal growing OSM adoption through shared knowledge including organisational and industry learning. Growth will be evidenced by higher levels of OSM Project Team member expertise and domestic supplier capability and capacity throughout the construction sector.

Project:
Client:

Question R1: What are the risks involved when using an OSM method?	Weighting	Score	Point

Question D1: What methods are used to adapt the Detail Design to include the available OSM components?	Weighting	Score	Point
Question D2: What processes have been developed to ensure Detail Design coordination for OSM components?	Weighting	Score	Point
Question D3: What design standards must be met by OSM components	Weighting	Score	Point
Question D4: Is "constructible" Building Information Modelling used in the project?	Weighting	Score	Point
Question D5: What are the building tolerance standards?	Weighting	Score	Point
Question P1: What are the construction site characteristics?	Weighting	Score	Point
Question P2: Is OSM capacity available?	Weighting	Score	Point
Question P3: Is OSM capability available?	Weighting	Score	Point
Question P4: What are the OSM components quality control systems?	Weighting	Score	Point
Question P5: How is on-site installation accuracy for OSM components achieved?	Weighting	Score	Point
Overall	0	0	0

Step 2—OSM_KnowledgeBank

Step 3

Step 3 involves evaluating either an OSM project or project team by calculating a single numerical indicator. The indicator is the total of ratings of each of the nineteen essential OSM questions, weighted according to project specific relative importance illustrated above. Each question is rated based on a weighted 1–5 scale designed to assess experience and skills and capacity.

- A high number (over 300) indicates significant OSM stakeholder capability with the potential to deliver the befits of OSM.
- A low number (below 150) indicates that that the project has inadequate OSM capacity to benefit from an OSM procurement model
- Scores in between indicate a project that has the potential to take advantage of an OSM procurement model but it is likely to be difficult and risky.

Only projects with a high score should proceed to use OSM procurement and equally if OSM is intended, team members should be selected based on a high individual score.

Score	OSM Capability
300–475	Project has **significant** capability indicating likely OSM success
150–299	Project has **minimum** capability indicating potential OSM success
0–149	Project has **inadequate** capability for OSM procurement indicating OSM would be risky

Step 3—Evaluation

STEP 1: CONSIDERATION OF KEY OSM ISSUES

Step 1 of the three-step *OSM Readiness Tool* considers the environmental factors that influence decision making. Step 1 defines two aspects of OSM readiness by addressing four categories of environmental issues and mapping associated stakeholder responsibilities. These Key OSM issues and responsibilities should be considered after the project requirements have been identified but before the feasibility study is completed.

Introduction

Environment

Issues of OSM capacity and capability in relation to building constructability should be addressed in the feasibility study to ensure that value for money is appropriately gauged[1].

This section provides a short discussion of problems and solutions for each of the identified

Step 1—Environmental issues

Key OSM Issues: Risk, Knowledge, Management, Design and Procurement.

The *OSM Readiness Tool* provides a method of comparison of conventional and OSM procurement strategies to assist in understanding **risks** related to adopting a new procurement model.

The extent of available **knowledge management** effects the transition to the OSM procurement model for individual projects. The approach suggested in this report is a systematic method for identifying and collecting essential types of OSM capability plus capacity information about both professionals and suppliers.

Industry stakeholders interviewed for this research agree that 'the earlier the better' is crucial for adoption of an OSM construction model. This means integrating OSM in **design** stages to minimise risk for **procurement** decisions.

1 Palaneeswaran, E., Kumaraswamy, M. & Ng, T. (2003) Targeting optimum value in public sector projects through 'best value'-focused contractor selection. *Engineering, Construction and Architectural Management*, **10**, 418–31.

Project Stakeholders

Stakeholder	Acronym	Description
Clients/Owners	CL	Government agencies or private companies responsible for initiating a construction project.
Project Team	PT	A generalised ideal Project Team for OSM construction projects includes: client, project manager, architect, engineer consultant, OSM manufacturers, construction manager, builder, sub-contractors, and suppliers.
Project Manager	PM	An individual or company responsible for oversight of the construction project.
Construction Manager	CM	An individual or company responsible for on-site construction of a building.
Quantity Surveyor	QS	An independent individual or company responsible for cost management.
Architect	AR	An individual or company responsible for creating the architectural design of the building.
Engineer Consultants	EC	Individuals with specific occupational skills responsible for creating the engineering design including (but not limited to): • Structural Engineers • Electrical Engineers • Mechanical Engineers • Lighting Engineers • Facade Engineers
General Contractor/ Builder	GC	A company or group of companies responsible for the construction process in the construction project.
Sub-contractors	SC	A company or group of companies responsible for providing designed construction process.
OSM manufacturers/ suppliers	MS	A company that supplies raw materials or assembled materials to the construction project.

Project stakeholder acronyms

Adopting an OSM procurement model requires mechanisms to enable successful transition from conventional project delivery systems to a relationship-based system. The four environmental issues identified are considered essential for providing OSM information necessary to build a competent OSM Project Team.

Early analysis of experienced OSM professionals will facilitate building of a skilled Project Team that can match OSM component production with project specifications and project duration.

The following table presents a matrix of capability, capacity and responsibility for team members for key environmental issues. This connects project team members responsible for OSM information collection and OSM decision making.

Key OSM issues	OSM Capability	OSM Capacity	Q#	OSM Information Management / Responsibility
RISK				
OSM risk analysis	X	X	R1	PM
Comparative procurement models project cost analysis	X	X	R2	PM
Comparative procurement models project duration analysis	X	X	R3	PM
Identified OSM experience of Project Manager	X		R4	CL/PM
KNOWLEDGE MANAGEMENT				
Identified OSM experience of Architect	X		KM1	PM
Identified OSM experience of Design Engineer	X		KM2	PM
Identified OSM experience of Contractor	X		KM3	PM
OSM project communication protocol analysis	X	X	KM4	PM
OSM products details	X	X	KM5	PM/MS
DESIGN				
Integrating OSM into Detail Design	X	X	D1	PM/AR/EC
Design integration & OSM coordination processes	X	X	D2	PM
Design Standards for OSM products	X	X	D3	AR/EC/MS
BIM constructability compatibility	X	X	D4	PM
Integrating BIM building tolerance standards	X	X	D5	AR/EC/MS
PROCUREMENT				
Construction site OSM compatibility	X	X	P1	PM
OSM capacity		X	P2	PM/MS
OSM capability	X		P3	PM/MS
Constructbile BIM for OSM site set out	X	X	P4	CM/GC/MS
Integrating OSM quality control systems	X	X	P5	PM/MS

Key OSM Issues for a systematic collection of essential types of OSM capability and capacity information including:

1 Indication (X) whether or not the issue relates to capability or capacity (most provide information for both)
2 Individual issue identifier (same as the OSM_KnowledgeBank template question)
3 OSM stakeholder responsible for OSM information identification and collection

Key Issues: Capability, Capacity and Responsibility matrix

Risk

Key OSM issues	OSM Capability	OSM Capacity	Q#	OSM Information Management / Responsibility
RISK				
OSM risk analysis	X	X	R1	PM
Comparative procurement models project-cost analysis	X	X	R2	PM
Comparative procurement models project-duration analysis	X	X	R3	PM
Identified OSM experience of Project Manager	X		R4	CL/PM

OSM Risk Analysis

OSM method problem: As with all construction methods, a project risk analysis is required. However, unfamiliarity with OSM means that special attention to the complexity of OSM procurement and supply options are required.

OSM adoption activities: The Project Manager is responsible for identifying specific risks associated with OSM adoption during the conceptual design stage. A risk reduction strategy should be developed for (but not limited to):

- Financial complexity
- Technical specifications
- Procurement processes
- Manufacturing processes
- OSM integrated construction processes
- Health and safetyfor all production locations
- Community acceptance of OSM production processes

Each identified risk needs a well-defined reduction strategy as part of the project Risk Management Plan.

The list above contains general OSM risk issues to be considered, but all unique OSM projects also have specific potential risks that need to be considered and be included in the risk management plan.

OSM_KnowledgeBank:

An OSM risk analysis template is provided at: http://www.sbenrc.com.au.

Question: R1:
What are the risks involved when using an OSM method?

Project Cost Comparison for Different Procurement Methods

OSM method problem: It is often argued that the OSM methods are more expensive when compared with the conventional Design-Bid-Build method. This may be true if differences between direct and indirect costs are not taken into consideration during cost planning[2]. However, full analyses of both types of costs should be considered in the cost planning.

OSM adoption Activities: The Project Manager is responsible for ensuring inclusion of both direct (on-site) and indirect (off-site) cost breakdown for all processes in the construction chain:

- Conceptual Design
- Detail Design
- Manufacturing
- Pre-construction
- Construction
- Post-construction

Comparison of total project cost is necessary for a number of procurement methods to provide accurate value for money estimates with consideration of (but not limited to):

1. Conventional construction method—Design-Bid-Build
2. OSM construction method—Design & Build
3. Other OSM construction delivery methods.

Early Contractor Involvement (ECI) project delivery methods are gaining acceptance in Australia. ECI is particularly suited to OSM construction allowing issues of constructability to be integrated into the Detail Design before finalisation. In addition, early involvement of all OSM stakeholders enables the Project Team to maximise the benefits of an OSM delivery model.

OSM_KnowledgeBank:

An OSM cost comparison template is provided at: http://www.sbenrc.com.au.

Question: R2:
How does project cost for an OSM method compare with a conventional construction method cost?

Project Duration Delivery Method Comparison

OSM method problem: An industry perception that OSM components require long lead-times may prejudice the use of OSM. However, project duration also has direct and indirect duration factors. Conventional project delivery methods often ignore shortages of labour, interrupted materials delivery and rework in a calculation of project duration. An OSM project delivery method contributes to reducing the overall project duration because parallel production processes allow for increased quality control. Control of delivery times can also reduce material and human resources waste as well as re-work.

OSM adoption Activities: The Project Manager is responsible for including both direct (on-site) and indirect (off-site) duration breakdown for all processes in the construction chain:

- Conceptual Design
- Detail Design
- Manufacturing

2 Baldwin, A.N., Shen, L.Y., Poon, C.S., Austin, S.A. & Wong, I. (2008) Modelling design information to evaluate pre-fabricated and pre-cast design solutions for reducing construction waste in high rise residential buildings. *Automation in Construction*, **17**, 333–41.

- Pre-construction
- Construction
- Post-construction

Comparison of total project duration is necessary for a number of procurement methods to provide accurate value for money estimates with consideration of (but not limited to):

1. Conventional construction method—Design-Bid-Build
2. OSM construction method—Design & Build
3. Other OSM construction delivery methods.

Early Contractor Involvement (ECI) project delivery methods are gaining acceptance in Australia. ECI is particularly suited to OSM construction allowing issues of constructability to be integrated into the Detail Design before finalisation. In addition, early involvement of all OSM stakeholders enables the Project Team to maximise the benefits of an OSM delivery model.

OSM_KnowledgeBank:

An OSM duration comparison template is provided at: http://www.sbenrc.com.au.

Question: R3:
How does project duration for an OSM method compare with conventional construction method duration?

Project Manager OSM Experience

OSM method problem: For Project Teams with little OSM experience as a construction delivery method, OSM projects can be challenging and risky. A highly effective risk management strategy is to ensure the Project Manager has significant OSM project experience.

OSM adoption Activities: The responsibility of the Client and the Project Manager is to provide reassurance for the Project Team stakeholders[3] that the project is managed from an OSM perspective. The Project Manager's OSM experience should include (but not be limited to):

General Details:

1. Number of years of OSM experience
2. Number of OSM projects.

Specific OSM Project Details:

1. Building types
2. Company details
3. Scope of the OSM in previous projects
4. Financial benefits of OSM in project
5. Non-financial benefits of OSM in project.

Details of OSM experience related to building types provide an indication of the extent of OSM expertise. Specific project details are necessary for OSM delivery method experiences in relation to building type, for example (but not limited to):

- Commercial
- Residential
- Government
- Industrial
- Educational
- Transportation Stations
- Parking and Storage
- Military

OSM_KnowledgeBank:

An OSM experience template is provided at: http://www.sbenrc.com.au.

Question R4:
What is the range of the Project Manager's OSM experience?

3 Boyd, D. and Chinyio, E. (2006) *Understanding the Construction Client*, Blackwell Publishing, Oxford, UK.

Knowledge Management

Key OSM issues	OSM Capability	OSM Capacity	Q#	OSM Information Management / Responsibility
KNOWLEDGE MANAGEMENT				
Identified OSM experience of Architect	X		KM1	PM
Identified OSM experience of Design Engineer	X		KM2	PM
Identified OSM experience of Contractor	X		KM3	PM
OSM project communication protocol analysis	X	X	KM4	PM
OSM products details	X	X	KM5	PM/MS

OSM Stakeholder Experience

OSM method problem: For Project Teams with little experience of the construction delivery method, OSM projects can be challenging. A highly effective knowledge management strategy is to ensure that the Project Manager has significant OSM experience. Identifying other industry stakeholders with a range of OSM project delivery experience will strengthen the knowledge transfer mechanisms necessary for effective OSM project procurement.

OSM adoption Activities: The responsibility of the Project Manager is to identify stakeholders with OSM experience thus providing crucial information concerning OSM components to the design team. Early involvement with suppliers, manufactures and builders with OSM experience will decrease the project risk. Details of all the stakeholders' OSM experience should include (but not be limited to):

General Details:

1 Numb of years OSM project experience
2 Number of OSM projects.

Specific Project Details:

1. Building types
2. Company details
3. Scope of the OSM in previous projects
4. Financial benefits of OSM in project
5. Non-financial benefits of OSM in project.

Details of OSM experience related to building types provides an indication of the extent of OSM expertise. Specific project details are necessary for OSM delivery method experiences in relation to building type, for example (but not limited to):

- Commercial
- Residential
- Government
- Industrial
- Educational
- Transportation Stations
- Parking and Storage
- Military

Gathering stakeholder OSM experience details is a mechanism that can assist with knowledge transfer and sharing of personal OSM expertise across the project. For example, if OSM knowledge is exchanged before Detail Design finalisation, there are more opportunities to minimise waste and maximise effectiveness.

Initial OSM building experience should be obtained from: the Architect, the Design Engineer and a potential Contractor. As indicated above, early contractor involvement is an important feature of an effective OSM project delivery method[4].

OSM_KnowledgeBank:

OSM experience templates are provided at: http://www.sbenrc.com.au.

Question KM1:
What is the range of the Architect's OSM experience?

Question KM2:
What is the range of the Consultant Engineer's OSM experience?

Question KM3:
What is the range of the Contractor's OSM experience?

OSM Project Communication Protocol

OSM method problem: OSM design processes require highly accurate information exchange between difference stakeholders in the Project Team. The entire Project Team requires an integrated communication system that supports an OSM procurement method. To ensure on-site and off-site connectivity an analysis of project stakeholder communication systems is necessary.

OSM adoption Activities: The Project Manager is responsible for identifying all stakeholders involved in the project. Details for stakeholders to include (but not limited to):

1. Stakeholder, role and responsibility:
   - Architect
   - Structural Engineer
   - Transport Director
   - Environmental Manager
   - Mechanical Engineer
   - Electrical Engineer
   - Plumbing Designer
   - Interior Designer
   - Quantity Surveyor
   - Builder
   - Mechanical-Contractor
   - Quality Control Coordinator
   - Electrical-Contractor
   - Plumbing-Contractor
   - Factory Manager
2. Company details
3. Scope of responsibility within the OSM construction project
4. Communication software being used;
   - e.g. Aconex.

Knowledge sharing for construction projects is an important business strategy. All stakeholders are expected to engage in knowledge sharing for a more effective and sustainable construction outcome[5].

A project communication protocol at the earliest stages of the building project is the basis of a

4 Song, L., Mohamed, Y. and AbouRizk, S.M. (2009) Early contractor involvement in design and its impact on construction schedule performance. *Journal of Management in Engineering*, **25**(1), 12–20.

5 Egbu, C. (2012) *Construction Innovation through Knowledge Management: Construction Innovation and Process Improvement,* Wiley-Blackwell, London.

knowledge sharing community of practice necessary to support an OSM project delivery method. Effective and efficient knowledge transfer, in a number of specialist formats, is a principle requirement for OSM benefits to be measurable in a building project.

OSM_KnowledgeBank:

An OSM communication protocol template is provided at: http://www.sbenrc.com.au.

Question KM4:
What is the project communication protocol?

OSM Products Information

OSM method problem: An OSM delivery method requires accurate OSM product information, based on both supplier capability and capacity. It is important for architects and design engineers in the Project Team to have this information during their development of the Detail Design. Because the requirements of OSM components are crucial for an accurate Detail Design, identification of the availability of the OSM components details should be investigated before the Detail Design process begins.

OSM adoption Activities: The responsibility of the Project Manager along with Manufacturers and Suppliers are to ensure relevant information concerning OSM products capacity and capability is readily available to the Detail Design team.

Details of OSM building components product types should include (but not be limited to):

- Substructure
- Superstructure
- Concrete structure
- Concrete structure
- Smart monitoring systems
- Roof
- Interior doors & frames
- Mechanical system
- Electrical system
- Steel structure
- Facade
- Modular room units

Products Details required are:

1. Complying standards; e.g. AS/NZS
2. CAD details
3. BIM details.

OSM_KnowledgeBank:

An OSM product details template is provided at: http://www.sbenrc.com.au.

Question KM5:
What OSM products details are available for designers before the Detail Design process begins?

Design

Key OSM issues	OSM Capability	OSM Capacity	Q#	OSM Information Management / Responsibility
DESIGN				
Integrating OSM into Detail Design	X	X	D1	PM/AR/EC
Design integration & OSM coordination processes	X	X	D2	PM
Design Standards for OSM products	X	X	D3	AR/EC/MS
BIM constructability compatibility	X	X	D4	PM
Integrating BIM building tolerance standards	X	X	D5	AR/EC/MS

Integrating OSM into Detail Design methodology

OSM method problem: The conventional procurement method for building construction assumes a level of measurement accuracy that has a significant amount of adaptability. However, OSM components are produced with the expectation of reducing human and material resources waste by more ridged adherence to uniform and highly accurate measurement. The design team needs to have the experience and skills to change calculation methodologies to accommodate the highly accurate and standardised OSM building components.

OSM adoption Activities: The responsibility for analysing technical specifications of OSM components to ensure accurate calculations is led by the Project Manager, the Architect and the Consulting Engineer. They need to work closely with other stakeholders to obtain, and distribute the OSM product knowledge so it is integrated into the final Detail Design.

Two important questions need to be asked:

1. What design Methodology was changed? e.g. from X to Y
2. What were the reasons for changing the design methodology?

Each of these questions needs to be asked in relation to all OSM components. For example (but not limited to):

- Steel Beams
- Steel Columns
- Concrete Floor
- Duct Work
- Demountables
- Modular shower and toilet cubicles

If OSM knowledge is exchanged before Detail Design finalisation, there are more opportunities to minimise waste arising from design inaccuraciesand and maximise effectiveness because of highly accurate measurements for OSM components.

OSM_KnowledgeBank:

An OSM design adaptation methodology analysis template is provided at: http://www.sbenrc.com.au.

Question D1: What methods are used to adapt the Detail Design to include the available OSM components?

Detail Design Coordination Processes

OSM method problem: In most conventional construction methods Detail Design is performed without construction coordination by the Construction Manager during the preparation of the shop drawings. Considerations of constructability are only considered through re-design at this late stage coordination which can be costly for the building project.

Adopting an OSM method provides an opportunity to change how both the Detail Design and Shop drawings are produces, by integrating OSM technical specifications with project requirements at an early stage. The best way to achieve this is to develop an OSM Integration Detail Design Coordination Protocol[6].

OSM adoption Activities: The Project Manager is responsible for developing an OSM Integrated Detail Design Coordination Protocol for the project.

The important questions to be considered by a variety of Project Team stakeholders include:

1. Has coordination between stakeholders been considered during:
   - Conceptual Design?
   - Detail Design?
   - Manufacturing?
   - Pre-construction?
2. Have transportation requirements and implications been considered for all phases?
3. What organisations are responsible for scoping OSM coordination?

Details for the OSM Integration Detail Design Coordination Protocol can identify specific OSM components and the number of Project Team stakeholders concerned with each type. Specific projects may utilise OSM components including (but not limited to):

- Foundation work
- Structural work
- Facade work
- Roof work
- Interior work
- Mechanical work
- Electrical work

The promise of OSM is to reduce waste by providing building components in a quality controlled environment. This is more probable if a high level of coordination takes place between stakeholders during both the Detail Design and the Build phases.

OSM_KnowledgeBank:

An OSM design coordination analysis template is provided at: http://www.sbenrc.com.au.

Question D2:
What processes have been developed to ensure Detail Design coordination for OSM components?

Integrating Detail Design Standards into OSM

OSM method problem: OSM component characteristics are different from traditional building components. As a result designers need to select design and calculation methods able to integrate the characteristics of the OSM components. For example, factory produced and assembled components specifications for

6 Smith, R., E. (2010) *Prefab Architecture: A Guide to Modular Design and Construction*, John Wiley & Sons, Inc., New Jersey.

Examples of building components	System type	Required standard	Why was this standard selected?
Building structure	Structural design actions—General principles	AS/NZS 1170.0:2002	*Insert reason*
Steel structure	Steel reinforcing material	AS/NZS 4671:2001	*Insert reason*

disassembly or ridged modular packages impact on materials standards and local building codes[7].

OSM adoption Activities: The Project Team needs to identify OSM component impact on the building design and compliance issues to ensure design standards are integrated. A cooperative environment with all AEC stakeholders is necessary to take advantage of opportunities presented by an OSM procurement method. The Architect, Engineering Consultant, Manufacturers and Suppliers have the responsibility for collating OSM product standards details that include (but are not limited to) are shown in the table above.

An analysis of OSM impact on the selection of design standards early in the Detail Design process will maximise OSM benefits. The important issue of selection criteria must be understood as both a limiting factor and an opportunity for innovation.

Stakeholders providing details of OSM possibilities through a knowledge management system will assist the various Project Team members with their tasks.

OSM_KnowledgeBank:

An OSM design standard analysis template is provided at: http://www.sbenrc.com.au.

Question D3:
What design standards must be met by OSM components?

Constructible BIM Compatibility

OSM method problem: It is often the case that designers have limited knowledge of the execution of construction, especially in relation to OSM components. Detail Design for an OSM model of construction contains extensive levels of detail. To communicate these details, the IT systems used to generate technical drawings must be precise to ensure manufacturing accuracy.

Building Information Modelling (BIM) is becoming the international standard[8]. However, currently Design BIM is not able to provide the highly accurate levels of measurement and product details necessary for *Constructible BIM* (BIM models designed for constructability and collaboration) that enable OSM models of construction to be effective.

OSM adoption Activities: The Project Manager is responsible for ensuring a Project Communication Protocol and the OSM Integration Detail Design Coordination Protocol

7 Gil, N., Tommelein, I.D., Kirkendall, R.L. and Ballard, G. (2000) Contribution of specialty contractor knowledge to early design, *Proceeding of the 8th Annual Conference of the International Group for Lean Construction*, Brighton, UK, 12pp. http://www.iglc.net.

8 Eastman, C., Teicholz, P., Sacks, R. and Liston, K. (2011) *BIM Handbook: A Guide to Building Information Modelling for Owners, Managers, Designers, Engineers, and Contractors*, John Wiley & Sons, New Jersey.

that includes BIM capability and capacity within the project systems. Details concerning BIM capability should be obtained from (but not limited to):

1. Stakeholder, role and responsibility
   - Architect
   - Structural Engineer
   - Transport Director
   - Environmental Manager
   - Mechanical Engineer
   - Electrical Engineer
   - Plumbing Designer
   - Interior Designer
   - Quantity Surveyor
   - Builder
   - Mechanical-Contractor
   - Quality Control Coordinator
   - Electrical-Contractor
   - Plumbing-Contractor
   - Factory Manager
2. Company details
3. Software being used with OSM production capability, e.g. Autodesk Navis Works for design; iConstruct for Construction BIM.
4. Scope of Responsibility within the OSM construction project.

OSM_KnowledgeBank:

A BIM constructability analysis template is provided at: http://www.sbenrc.com.au.

Question D4:
Is "Constructible" Building Information Modelling used in the project?

Integrating BIM building Tolerance Standards

OSM method problem: During Detail Design of a building project, levels of tolerance are expected to meet industry and code standards. Sections of the building, such as outside facade and interior walls, have different tolerance standards. OSM products are also produced to tolerance standards, but to higher levels of tolerance accuracy. Therefore during Detail Design development, accurate integrated design will ensure that OSM components produced by different manufacturers fit together and can be integrated with on-site building tolerance standards.

OSM adoption Activities: The Project Team members should take responsibility during the design process for identifying the building tolerance standard of each OSM component.

The analysis is based on two questions:

1. What standards have been used?
2. Is this tolerance standard included in the BIM?

OSM components to be considered include (but are not limited to):

- Structural work
- Facade work
- Foundation work
- Site preparation work
- Piping work
- Roof work
- Interior work
- Mechanical work
- Electrical work
- Overall work

OSM_KnowledgeBank:

An OSM building tolerance analysis template is provided at: http://www.sbenrc.com.au.

Question D5:
What are the building tolerance standards?

Procurement

Key OSM issues	OSM Capability	OSM Capacity	Q#	OSM Information Management / Responsibility
PROCUREMENT				
Construction site OSM compatibility	X	X	P1	PM
OSM capacity		X	P2	PM/MS
OSM capability	X		P3	PM/MS
Constructible BIM for OSM site set out	X	X	P4	CM/GC/MS
Integrating OSM quality control systems	X	X	P5	PM/MS

OSM compatible construction site characteristics

OSM method problem: The building site for all types of procurement methods are constrained by a number of local, state and commonwealth government regulations for traffic control, utilities use, environmental management, land use and health & safety procedures, etc. All government agencies concerned with procurement have guidelines and policies for construction of buildings. Currently very few regulatory documents mention OSM as a possible procurement method.

Lack of regulation for an OSM model of construction is concerning because of the large size of some OSM components, and the necessity of transporting them from one production location to another.

OSM adoption Activities: It is the responsibility of the Project Manager to ensure the building site is OSM ready. Early Project Team stakeholder coordination for an OSM procurement method will provide early consideration of necessary project-specific production, transportation and installation details[9].

Questions to enable the early integration of OSM into the Conception or Detail Design concerning the building site include (but not limited to):

1. Local infrastructure utilities such as water & electricity
2. Site accessibility for OSM transported components
3. Limitation posed to delivery of OSM components by the built environment
4. Site accessibility authorisation
5. Community issues related to OSM delivery and installation.

An early analysis of compliance issues and special consideration authorisations required, will contribute to the identification of both the direct and indirect costs. Identification of site characteristics will also provide details for coordinating manufacturing, transportation and project communication protocols.

9 Forbes, L.H. and Ahmed, S.M. (2011) *Modern Construction: Lean Project Delivery and Integrated Practices*, CRC Press, Boca Raton.

OSM_KnowledgeBank:

An OSM construction site analysis template is provided at: http://www.sbenrc.com.au.

Question P1:
What are the construction site characteristics?

Available OSM Capacity

OSM method problem: A lack of local capacity is often cited as a reason for not using an OSM procurement method. However, the vicious circle of not adopting an OSM procurement method means under-utilisation of capability, which leads to reduction in production capacity.

Consideration of OSM capacity is important because some manufacturers have limited capacity, while other manufacturers may be in an expansion phase. Availability of materials (other commitments) also impacts on OSM manufacturer capacity.

Early adoption of an OSM construction model can be based on current and potential OSM capacity.

OSM adoption Activities: The Project Manager is responsible for engaging with potential Manufacturers and Suppliers before the design process begins to ascertain OSM component capacity. Three types of information will assist the Project Team decision making:

1. OSM manufacturer details
2. Available OSM Component Materials
3. OSM Manufacturer Capacity

The information from these three questions is required for OSM components including (but not limited to):

- Steel Beams
- Steel Columns
- Concrete Floor
- Duct Work
- Demountables
- Modular shower and toilet cubicles

Early integration of OSM components into a building project Detail Design means efficient procurement processes are being utilised.

OSM_KnowledgeBank:

An OSM capacity analysis template is provided at: http://www.sbenrc.com.au.

Question P2:
Is OSM capacity available?

Available OSM capability

OSM method problem: Perceived absence of local OSM capability has been attributed to lack of stakeholder confidence in OSM procurement. However, this perception is usually based on attempting to add OSM components into a building project after the Detail Design has been completed. Integrating OSM into the project at an early stage, by choosing the OSM procurement model, supports a more effective and efficient project.

OSM adoption Activities: The Project Manager is responsible for identifying and collecting information on OSM component capability from potential Manufacturers and Suppliers before the design process begins. Four types of information will assist the Project Team:

1. Available OSM skilled labour
2. Available OSM manufacturing local facilities
3. Available OSM manufacturing remote facilities
4. Available OSM transportation

This information is required for OSM components including (but not limited to):

- Steel Beams
- Steel Columns
- Concrete Floor
- Duct Work
- Demountables
- Modular shower and toilet cubicles

Early analysis of available OSM capability will benefit all phases of a project ensuring early matching of OSM component production with project specifications and project duration.

OSM_KnowledgeBank:

An OSM capability analysis template is provided at: http://www.sbenrc.com.au.

Question P3:
Is OSM capability available?

Integrating OSM Quality Control Systems

OSM method problem: The concern with lack of quality for OSM components is often a mis-representation of the problem of ineffectual transfer of Detail Design. The problem is usually related to the lack of understanding of how important detail accuracy is to the design of the OSM components. All manufacturing processes have quality control systems in place, as do building projects. Project Team members sharing quality control system information is another integrating process required for an effective OSM procurement model.

OSM adoption Activities: The Project Manager, OSM Manufacturers and Suppliers are responsible for providing information concerning quality control systems[10]. The four questions concerning quality control systems relate to locations of OSM products.

1. What quality control system is used in OSM manufacturing?
2. What quality control system is used in OSM transportation?
3. How is the OSM component quality control system incorporated with the construction site quality control system?
4. What organisations are responsible for scoping OSM quality control?

Each of these four questions requires answers regarding OSM components such as (but not limited to):

- Site preparation work
- Foundation work
- Structural work
- Facade work
- Roof work
- Interior work
- Mechanical work
- Electrical work
- Piping work
- Overall work

Quality control systems provide an opportunity to consider not only the OSM products, but also the OSM production, transportation, and installation processes. These types of information can support the Project Team analysis of both direct and indirect project costs. Performance monitoring and evaluation are also activities that rely on detailed outputs from quality control systems.

OSM_KnowledgeBank:

An OSM quality control systems analysis template is provided at: http://www.sbenrc.com.au.

10 Rumane, A.R. (2010) *Quality Management in Construction Projects*, CRC Press, Boca Raton.

Question P4:
What are the OSM components quality control systems?

Constructible BIM for OSM Building Site Set-out

OSM method problem: A perceived problem of OSM component constancy is usually related to the lack of understanding the importance of measurement accuracy for the OSM components. Overcoming problems with measurement can be achieved by early analysis of the requirements for measurement accuracy in OSM components.

OSM components are designed to a high level of specification accuracy possible in factory production. In addition, specification accuracy to the highest level aims to ensure that every OSM component will fit during on-site installation. OSM component installation accuracy is assisted by site set-out tools and methodologies.

OSM adoption Activities: The Project Manager is responsible for coordinating installation of OSM components by identifying the set-out methodologies, technologies and measurement accuracy necessary and is assisted in this process by both Manufacturers and Suppliers.

The analysis of set-out processes needs to take into account three questions:

1. What are site set-out methodologies?
2. What technologies are used to ensure timely installation of OSM components?
3. What range of accuracy is expected?

The three questions above require answers for OSM components including (but not limited to):

- Site preparation work
- Foundation work
- Structural work
- Facade work
- Roof work
- Interior work
- Mechanical work
- Electrical work
- Piping work
- Overall work

In addition, more effective integration of OSM components is possible by providing transfer of accurate dimensions and measurements of OSM design from the Constructible BIM to the construction site. It would also be judicious to identify the tools to be used during the site set-out process necessary for tolerance standards.

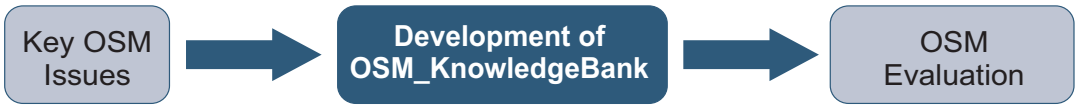
OSM_KnowledgeBank:

An OSM site set out analysis template is provided at: http://www.sbenrc.com.au.

Question P5:
How is on-site installation accuracy for OSM components achieved?

STEP 2: DEVELOPMENT OF OSM_KNOWLEDGEBANK

The three-step *OSM Readiness Tool* provides a mechanism for building a Project Team (temporary project organisation). Step 2 is a method for gathering relevant information about potential team members and the capacity of the supply chain. Step 2 provides a tool that can form a database of OSM information— this is called the *OSM_KnowledgeBank.*



OSM_KnowledgeBank

Introduction

The type of OSM production capability expertise and capacity information necessary will vary depending on the requirements of each unique project and/or the range of Project Team industry stakeholders. Individuals, teams and organisations will be required to contribute capability and capacity OSM information in the identified framework.

OSM capability and capacity templates for the 19 essential questions are in electronic format and may be found at:
http://www.sbenrc.com.au

It is expected that, over time and with increasing use of an OSM model for construction, your OSM_KnowledgeBank will grow. A substantial OSM_KnowledgeBank is indicative of a mature OSM industry.

Instructions

The OSM_KnowledgeBank method is:

1. Consideration of Key OSM Issues—answers the 19 essential questions. Each question has a structured, guiding template formed in accordance with the question outline in Step 1.
2. Identification and collection of stakeholder OSM capability, expertise and capacity using the evaluation templates—this process is repeated for each stakeholder.
4. Uploading completed templates into the project OSM_KnowledgeBank.

The following example of a completed question template is provided to help explain the framework for essential OSM information. This presents the case of Procurement question P2 (*Is OSM capacity available?*). In this example, OSM information has been obtained from three manufacturers who have provided details about each case of steel beams, concrete columns and mechanical systems.

OSM Capability and Capacity Information Example

OSM components	OSM manufacturer details	OSM manufacturer materials availability	OSM manufacturer capacity
Steel beams	ASB Pty. Ltd	The company supplies: • I-Beam • Z-shape • HSS-Shape • C-Channel • T-Shape • Structure plates in all standard sizes.	ASB has capability of providing all types of structure steelwork prefabrication and all metal formwork. ASB has vast range of capacity from crane runway platform to a **3,000 ton per annum** distribution facility within Australia. For requirements greater than **3,000 ton** per annum, ASB has capability to deliver to clients within acceptable lead time. ASB has expertise to prefabricate heavy strain transmission towers, bridges beams, mining facilities, sporting stadiums, commercial building, office complex, shopping centre and processing plant both on-shore and off-shore.
Concrete columns	ACS Pty Ltd	The company supplies prestressed concrete beams, panels and slabs in various sizes.	ACS has capacity to manufacture prestressed beams exceeding **150 ton**. ACS also has capability to manoeuvre heavy concrete components which require specific attention. ACS has mobile crane with up **150 ton** capacity.
Mechanical work	MECH Pty Ltd	The company supplies round, rectangular and oval ductwork in various materials. These include galvanised steel, aluminium, stainless steel and fabric. The company also supplies various types of air-conditioning and ventilation system equipment.	MECH specialises in design and construction of mechanical systems. These include, design and construction of various types of air-conditioning systems: capacity varies from **100–750 ton** of air cooled air-conditioning system and **750–2,500 ton** water cooled conditioning system. In terms of air-side, WFA uses 3D BIM in various projects. The company also uses CAD-DUCT software to facilitate production process. MECH has capacity to manufacture ductwork and accessories at **30,000 m2 per month** and approximately **2,000 ton per year** of galvanized sheet. WFA ductwork can be semi-fabricated and prefabricated from the main factory.

Example of information collected for Question P2: Is OSM capacity available?

STEP 3: OSM EVALUATION

Step 3 of the three-step *OSM Readiness Tool* is a mechanism for rating OSM capability and capacity for both the Project Team and the building project.

Scoring system

The scoring system relates to the information obtained for the 19 essential question templates in the OSM_KnowledgeBank. Although the score is subjective, the OSM identification process provides an indicative number concerning both OSM capability and capacity for both the Project Team and OSM products. This number can then be considered as indicative of risk level and/or OSM readiness. Thus the Project Team could decide to proceed with an OSM procurement model or to revert to a more conventional construction model based on the total number of points.

The evaluation method for OSM Adoption is indicative of a participatory process:

1. Identifying, providing, collecting and collating the OSM capability and capacity information for the *OSM_KnowledgeBank* will be the responsibility of all stakeholders. However, much of the collection task is initially undertaken by for the Client and Project Manager.
2. The effectiveness of the *OSM Readiness Tool* will be based on the willingness of a majority of industry stakeholders to share their OSM knowledge.
3. Because building projects are unique, it is vital that all OSM stakeholders including Manufacturers, Contractors, Builders and Suppliers have input to the relative importance of each question during an OSM project evaluation. Consideration of the opinions of all Project Team stakeholders will provide a more effective OSM project.

How the Scoring System Works

An OSM capability and capacity score is based on a weighted 1–5 scale. A formula embedded in the OSM_KnowledgeBank provides a total score.

Scale

The scale is a range of 1–5. This range can be used for each question to indicate the significance of the information provided. In this scoring system 1 would probably indicate no OSM information is available and 5 would mean the most useful OSM information is available to the Project Team.

Weight

Weigh refers to the relative importance of the OSM information for the specific product. For example, a single-level, six classroom school building would have different technical specifications from a seven-level, multi-unit commercial building.

In a seven-level, multi-unit commercial building OSM requirements might include steel beams, air-circulation units and concrete columns because of mandatory building codes and standards. Each of these components can be produced on-site or off-site. The following table

Score	Steel Beam Manufacturers	Capability	Capacity
1	*No information in the template*	*No information in the template*	*No information in the template*
2	Manufacturer A	only one product	limited capacity and materials
3	Manufacturer B	range of products	range of capacity, but limited materials
4	Manufacturer C	only one product	limited capacity and materials
	Manufacturer D	range of products	range of materials but limited capacity
5	Manufacturer E	range of products, three locations	range of capacity and materials

Example of choosing a weight for steel beam capability and capacity from completed OSM template

provides an example of how weights could be applied, using the scale 1–5. Weight can be given to both OSM capability and capacity. Additional weighting is given for each extra level of positive capacity and capability.

Points

The formula for points is based on a weighted compilation of all scores for the 19 essential OSM question templates:

The Points for each question = Weighing X Score

The formula for total OSM points (*OSMP*) is:

$$OSMP = \sum_{i=1}^{i=n} \left(a_{j1} + b_{j2} + c_{j3} \ldots n_{jn} \right)$$

Where: i = the question number, n = the total number of questions (currently 19) and ji = weight relevant to each question

This calculation is embedded in the *OSM_KnowledgeBank* templates.

The table on the next page shows the example of weight, score and points for Question P2. Scores and weight are entered into the OSM evaluation question template. The total OSM score will automatically appear in the summary page of the *OSM_KnowledgeBank*.

An electronic version of the *OSM Readiness Tool* is available from *http://www.sbenrc.com.au*

Significance of Total Points

The OSM capability and capacity evaluation is based on a scoring system. The scoring system can be used in two ways:

1. A mechanism for building project team to adopt an OSM procurement model
2. A method for the Client and Project Team to assess their knowledge of OSM capacity and capability for a specific building project.

The maximum number of points is 475 indicating a Project Team with significant OSM expertise and access to both sufficient OSM domestic capacity and capability. Total points of 150 or less indicates little OSM expertise, and an OSM project delivery model should not be considered.

1. A Mechanism for Building Project Team to Adopt an OSM Procurement Model

An OSM Project Team with significant OSM expertise ensures a high level of OSM stakeholder engagement. High levels of engagement will ensure OSM capacity and capability knowledge is integrated early in the

Project: Perth Hospital **Client**: Government of Western Australia	Data collection responsibility	weight	Score	Points
	PM/MS	5	4	20

Question P2: Is OSM Capacity available?

OSM components	OSM manufacturer details	OSM manufacturer materials availability	OSM manufacturer capacity
Steel beams	ASB Pty. Ltd	The company supplies: • I-Beam • Z-shape • HSS-Shape • C-Channel • T-Shape • Structure plates in all standard sizes.	ASB has capability of providing all types of structure steelwork prefabrication and all metal formwork. ASB has vast range of capacity from crane runway platform to a **3,000 ton per annum** distribution facility within Australia. For requirements greater than **3,000 ton** per annum, ASB has capability to deliver to clients within acceptable lead time. ASB has expertise to prefabricate heavy strain transmission towers, bridges beams, mining facilities, sporting stadiums, commercial building, office complex, shopping centre and processing plant both on-shore and off-shore.
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Example of OSM information Weight, Score and Points for Question P2: Is OSM capacity available?

OSM construction process. High levels of OSM stakeholder engagement enables significant OSM input at the conceptual design, feasibility study and detail design phases assisting with OSM knowledge sharing within the Project Team.

An OSM Project Team with some OSM expertise will have the capability for a medium level of OSM stakeholder engagement. A Medium level of engagement means that OSM capacity and capability knowledge will be integrated into the project after the Detail Design is completed. A medium level of OSM knowledge sharing will assist the OSM Project Team but will not significantly expand Project Team capability and capacity.

An OSM Project Team with little OSM expertise will have difficulty engaging with a wide range of OSM stakeholders. Low levels of engagement probably means little OSM is integrated early in the construction process thus OSM will have little impact on either the Project Team or the building project.

2. A method for the Client and Project Team to assess their knowledge of OSM capacity and capability for a specific building project.

Explanations for three score scenarios for the total score range are provided in the adjacent table.

For each score range, the table provides a risk assessment and comments on the interpretation.

OSM Project scenarios for three point ranges	
Scenario 1: Total points between 301-475	This score range indicates low risk related to adopting an OSM model for the building project. Low risk is indicative of a high level of OSM knowledge and experience.
	• The Project Team is capable of completing an OSM customisation building project. • The Project Team has identified sufficient domestic OSM capability. • The Project Team has identified a critical mass of OSM suppliers with sufficient capacity.
Scenario 2: Total points between 151-300	This score range indicates a medium risk in adopting an OSM model for the building project. Medium risk is indicative of a moderate level OSM experience and knowledge.
	• The Project Team is capable of using a limited number of OSM components, (e.g. modular units with high volume) for a building project. • The Project Team has identified some OSM capability. • The Project Team has identified some OSM capacity, but below critical mass necessary for an OSM customised building project.
Scenario 3: Total points between 0-150	This score range indicates high risk in adopting an OSM model for the building project. High risk is indicative of little or no OSM experience and knowledge in the Project Team.
	• The Project Team has not identified sufficient OSM capability and capacity. • Consider obtaining more information about the OSM procurement model. • Consider building a broader OSM knowledge network.

No	ID	19 Essential Questions for *OSM_KnowledgeBank*
1	R1	What are the risks involved when using an OSM method?
2	R2	How does project cost for an OSM method compare with a conventional construction method cost?
3	R3	How does the project duration for an OSM method compare with a conventional construction method duration?
4	R4	What is the range of the project manager's OSM experience?
5	KM1	What is the range of the architect's OSM experience?
6	KM2	What is the range of the design engineer's OSM experience?
7	KM3	What is the range of the contractor's OSM experience?
8	KM4	What is the project communication protocol?
9	KM5	What OSM products details are available before the Detail Design development begins?
10	D1	What methods are used to adapt the Detail Design to include the available OSM components?
11	D2	What processes have been developed to ensure Detail Design coordination for OSM components?
12	D3	What design standards must be met by OSM components?
13	D4	Is "constructible" Building Information Modelling used in the project?
14	D5	What are the building tolerance standards?
15	P1	What are the construction site characteristics?
16	P2	Is OSM capacity available?
17	P3	Is OSM capability available?
18	P4	What are the OSM components quality control systems?
19	P5	How is on-site installation accuracy for OSM components achieved?

The 19 essential OSM questions that contribute to an OSM_KnowledgeBank *to form the basis for OSM Project Team or Building Project evaluation*

Sustainable Built Environment National Research Centre

SBEnrc Core Partners

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

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

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

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

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