

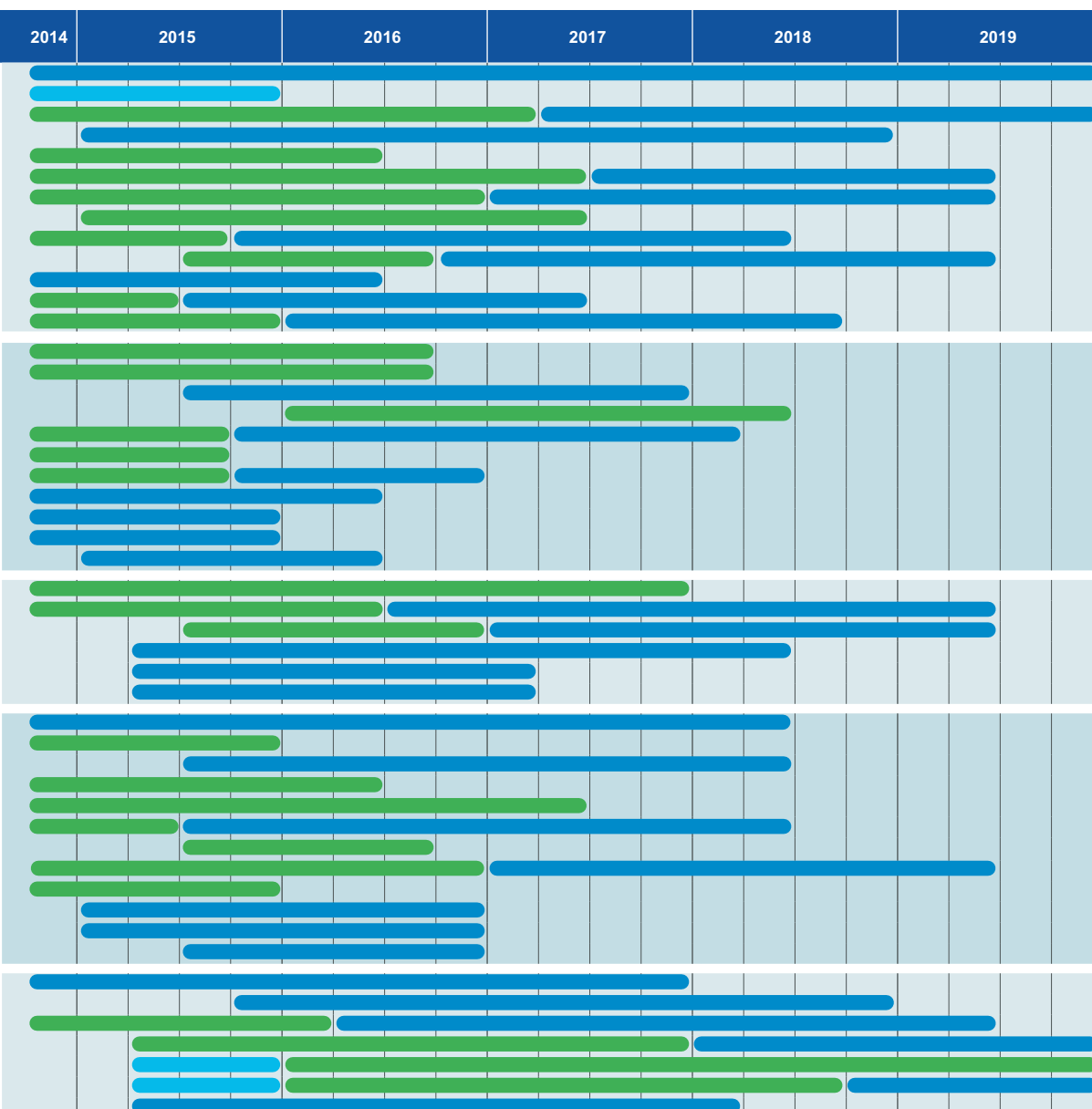


**Sustainable  
Built Environment**  
National Research Centre

Russell Kenley | Toby Harfield

# Location Importance in Infrastructure: New Project Management Structures

## SBEnrc Project 2.33



# Project Team

## Core members



## Acknowledgement

This research has been developed with funding and support provided by Australia's Sustainable Built Environment National Research Centre (SBEnc) and its partners. Core Members of SBEnc include Aurecon, Curtin University, Government of Western Australia, Griffith University, John Holland, New South Wales Roads and Maritime Services, Queensland Government, and Swinburne University of Technology.

The research team also acknowledges the contribution of interviewees who were a central part of this project.

The content of this publication may be used and adapted to suit the professional requirements of the user. It may be reproduced, stored in a retrieval system or transmitted without the prior permission of the publisher.

All intellectual property in the ideas, concepts and design for this publication belong to the Australian Sustainable Built Environment National Research Centre.

The authors, the Sustainable Built Environment National Research Centre, and their respective boards, stakeholders, officers, employees and agents make no representation or warranty concerning the accuracy or completeness of the information in this work. To the extent permissible by law, the aforementioned persons exclude all implied conditions or warranties and disclaim all liability for any loss or damage or other consequences howsoever arising from the use of the information in this publication.

### Publication of this book:

ISBN: 978-0-9943922-1-3

Published by SBEnc, Perth, Australia.

This book has been peer reviewed by independent reviewers.

## Project team members

### Project leader

Professor Russell Kenley  
(Swinburne University of Technology)

### Research team members

Dr Toby Harfield  
(Swinburne University of Technology)  
Dr Bill East (Prairie Sky Consulting)


### Industry team members

David Darwin (New Zealand Transport Agency)  
Belinda Stopic  
John Robertson  
Wayne Cannell  
(Main Roads Western Australia)  
Narelle Dobson  
(Qld Department of Transport and Main Roads)  
Chris Harrison (NSW Roads and Maritime Services)  
David Grenfell (John Holland Group)  
Carolyn Marshall (Department of Finance WA)  
John Martin (Aurecon)  
Harry Katsanevas (Position Partners)  
Rolf Büchmann-Slorup (MT Højgaard A/S)

# Australian Sustainable Built Environment National Research Centre

The Australian Sustainable Built Environment National Research Centre and its predecessor, the Cooperative Research Centre for Construction Innovation, have been committed to leading the Australian property, design, construction and facility management industry in collaboration and innovation. We have been dedicated to disseminating practical research outcomes to our industry—to improve business practice and enhance the competitiveness of our industry. Developing applied technology and management solutions, and delivering relevant industry information is what our Centre is all about.

We look forward to your converting the results of this applied research project into tangible outcomes and working together in leading the transformation of our industry to a new era of enhanced business practices, safety and innovation.



**John V McCarthy AO**

Chair  
Sustainable Built Environment National Research Centre



**Professor Keith D Hampson**

Chief Executive Officer  
Sustainable Built Environment National Research Centre

# Location Importance in Infrastructure: New Information Management Models

This work follows from SBEnrc Project 2.21: *New project management models: productivity improvement for infrastructure*. The research examined the role of location in new models for project management. There is duplication within existing structures and a new Short-Form Work Breakdown Structure (WBS) is proposed. A new *Construction to Operations for Network information exchange* is proposed and application made to continue research to design CONie.

## Theme 1: The effects of location in project management models

Location assumes a central role in construction management. It is routinely used by practitioners in the planning and management of their work. Location is used in many different life-cycle systems and such systems require location definition models. Theme 1 explores the effects in various aspects of Project Management.

### Empirical evidence for location repetition

This research provides the first empirical evidence for repetition of WBS elements across locations. Evidence for information repetition was found in infrastructure construction project documents. A clear picture emerged. Repetition in data was found to arise from operation repetition across discrete locational units.

### Framework and analysis

A new framework is presented based on an analysis of project WBS documents. Analysis of both Product (P) and Location (L) provided a categorisation that identified the dual nature of the WBS. The dual nature can be illustrated by using the symbols P and L to label individual items in a WBS.

### Short-Form WBS

It is recommended that a new Short-Form WBS be adopted as the outcome of a 2-dimensional matrix; the Product Breakdown (PBS) and the Location Breakdown (LBS). It is also recommended to adopt a strategy to target the revision and development of relevant International Standards.

## Theme 2: Location referencing for CONie (Construction to Operations Network information exchange)

Project 2.21 proposed the development of CONie: Construction to Operations for Network information exchange. CONie is a new suite of open standards and methods for implementing, testing, and enforcing the delivery of road construction information to operations handover.

### Lessons learned

Experience gained from past efforts in developing information exchange models for vertical infrastructure – COBie (Construction to Building information exchange) assists in creating a handover information exchange for horizontal infrastructure – CONie.

### Significance of location

Information exchange must refer to location through a location definition model. Current models for location referencing found in COBie are inappropriate for infrastructure networks. A key component of developing a CONie is to establish a linear reference model for horizontal infrastructure.

### International standards

It is recommended that CONie be developed as an International Standard. In this process, it is important to identify how and which international standards can be used to influence implementation of a new information exchange specification. A successful proposal for CONie development funding was an outcome of this research.

### Four recommendations

1. Develop a standard for a Short-Form WBS.
2. The research team should engage with processes to revise or develop standards that involve location for infrastructure.
3. Pursue the CONie specification: A new suite of open standards and methods for implementing, testing, and enforcing the delivery of road construction information to operations handover informed by lessons learned from COBie.
4. Further research into location definition models for roads and transport networks be undertaken.

## Executive Summary

This research focused on the role of location in project management structures. Theme 1 focused on identifying the effects of location repetition in construction management WBS decomposition resulting in a new matrix decomposition model Short-Form WBS for vertical infrastructure. Theme 2 expands on the notion of CONie as a New Information Model for horizontal infrastructure information exchange.

### The effects of location in Project Management models

The Project 2.21 Final Report recommended that productivity improvement might be possible by removing data repetition in project management models. However, this recommendation was deductive and has yet to be supported by empirical evidence of repetition.

Evidence for information repetition was found in infrastructure construction project documents. The research analysed project work breakdown structure definition documents, various types of construction schedules (Gantt Charts) and other project management documents which described the project WBS, from a wide range of infrastructure projects.

A clear picture emerged. Repetition in data was found to arise from operation repetition across discrete locational units. While the findings are not surprising, verification has not previously been empirically demonstrated.

To increase productivity, by reducing data repetition, a Project/Location matrix-based Short-Form is suggested as a New Information Management Model. This report recommends a matrix of project Product and project Location be developed for use in infrastructure project management. Such a method would provide a more concise description of a project WBS: A Short-Form WBS.

One of the primary mechanisms for advancing new project management structures is through acceptance in international standards. Analysis of existing and proposed WBS standards shows that they are based on long-established definitions and structures that are not easily modified. Therefore, a new Short-Form WBS is recommended to be developed as a new standard to enable industry to adopt this more efficient method.

### Location referencing for CONie (Construction to Operations Network information exchange)

The Project 2.21 Final Report recommended that productivity improvement could be possible for road and transport network asset management through the development of a new information exchange.

The suggested first step was to consider previous information exchange specifications that could provide lessons learned to ensure that the new specification would be generally accepted and integrated into current asset management systems.

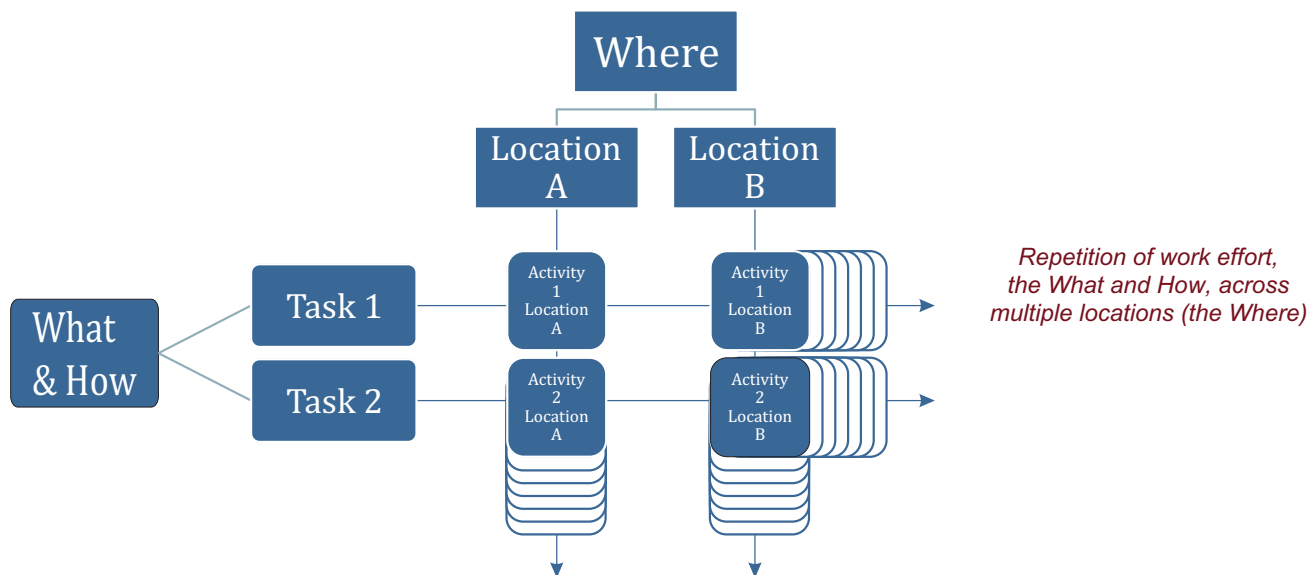
The development of an open standard COBie (Construction to Operations information exchange) for vertical infrastructure provided three important lessons to ensure that a new specification will be adopted:

- 1. understand the constraints
- 2. focus on who will use the standard
- 3. enable integration into existing practice.

Thus, development of a handover specification for road and transportation network Asset Management systems needs a CONie (*Construction to Operations for Network information exchange*) to be designed that is informed by these lessons.

In designing CONie, information must refer to location through a location definition model. Attention must be paid to the needs of multiple disciplines because end-users will have different perspectives.

Because location is a foundational concept that, once set, determines all subsequent systems, further research into location definition modes for roads and transport networks is recommended.



# Empirical Evidence for Location Repetition from Construction Project Management Documents

Location assumes a central role in construction management. It is routinely used by most practitioners in the planning and management of their work. However, it is not clear whether location data is problematic for management. This research provides the first empirical evidence for repetition of WBS elements across locations.

## The project WBS

The work breakdown structure (WBS), as embedded in most construction management documents and systems, remains as it was conceived in the early 1960s. The WBS method is based on a single hierarchal decomposition of the total work to be done. Work activities belong to the lowest level of the project WBS.

## Product decomposition

Although it is called a work breakdown structure, the WBS not only describes work required to deliver the project, but also displays and defines the product, or products, to be delivered.

A fully resolved WBS will contain work elements in all product components. Therefore, work can be expected to repeat wherever there is repetition in components.

Product components can be expected to repeat where building components exist in multiple locations. Therefore, WBS elements can be expected to repeat where there are multiple locations.

## Research questions

In many ways, the repetition of WBS elements across locations seems obvious. However, there is a dearth of empirical research concerning this type of repetition. A first research question is proposed:

1. Is there empirical evidence from real world construction projects for repetition of WBS elements across locations?

Given such evidence, a secondary research question would be:

2. Could the matrix view of project decomposition be a useful mechanism for highlighting data repetition?

Question 1 is the problem and Question 2 seeks a solution.

## Research method

Question 1 addresses repetition of WBS elements across locations. Implied in this question is the idea that repetition of an element will necessarily involve repeated work activities. Thus, repetition of the work activities may be handled by managing the elements in the lowest level of decomposition of the WBS. The research aim is to identify repetition of WBS elements.

A number of construction project WBS and schedule documents were collected from project managers, project planners and project schedulers. The documents (in both pdf and paper format) contain sufficient data to both:

- identify repetition of lowest level elements, and
- expose the way a work breakdown structure is influenced by the locations with a project.

For decomposed levels of each project WBS, the functional role of elements in that level were analysed. This involved categorisation according to two primary criteria as shown in Figure 1.

1. **Product breakdown:** the decomposition of building products according to some (often project specific) method. Examples are: Building (B01); Building Element (Super Structure); Building Sub-Element (Slab Work) and Component (Columns).
2. **Location breakdown:** the decomposition of the locations according to the project specific hierarchies. Examples are: Building (B01); Floor (Third Level) and Zone (Zone A).

Figure 1 provides an example of categorisation for a typical project. In this example, the allocation to Product or Location can be extracted from the coding structure of the WBS illustrated in Figure 2.

Type of Product	Sample WBS Notation	Location
Product	B01 Building	Building
Functional	B01.4 CONSTRUCTION	
Element	B01.4.3 Super Structure	
	B01.4.3.1 Ground Floor Level	Floor Level
Sub-element	B01.4.3.1.A Slab Work-Zone A	Zone
Component	B01.4.3.1.A.1 Column	
Component	B01.4.3.1.A.2 Shear Wall	
Component	B01.4.3.1.A.3 Slab	
	B01.4.3.2 First Floor Level	Floor Level
Sub-element	B01.4.3.2.A Slab Work-Zone A	Zone
Component	B01.4.3.2.A.1 Column	
Component	B01.4.3.2.A.2 Shear Wall	
Component	B01.4.3.2.A.3 Slab	
Sub-element	B01.4.3.2.B Slab Work-Zone B	Zone
Component	B01.4.3.2.B.1 Column	
Component	B01.4.3.2.B.2 Shear Wall	
Component	B01.4.3.2.B.3 Slab	
	B01.4.3.3 Second Floor Level	Floor Level
Sub-element	B01.4.3.3.A Slab Work- Zone A	Zone
Component	B01.4.3.3.A.1 Column	
Component	B01.4.3.3.A.2 Shear Wall	
Component	B01.4.3.3.A.3 Slab	
Sub-element	B01.4.3.3.B Slab Work- Zone B	Zone
Component	B01.4.3.3.B.1 Column	
Component	B01.4.3.3.B.2 Shear Wall	
Component	B01.4.3.3.B.3 Slab	
	B01.4.3.4 Third Floor Level	Floor Level
Sub-element	B01.4.3.4.A Slab Work- Zone A	Zone
Component	B01.4.3.4.A.1 Column	
Component	B01.4.3.4.A.2 Shear Wall	
Component	B01.4.3.4.A.3 Slab	
Sub-element	B01.4.3.4.B Slab Work- Zone B	Zone
Component	B01.4.3.4.B.1 Column	
Component	B01.4.3.4.B.2 Shear Wall	
Component	B01.4.3.4.B.3 Slab	
	B01.4.3.5 Fourth Floor Level	Floor Level
Sub-element	B01.4.3.5.A Slab Work- Zone A	Zone
Component	B01.4.3.5.A.1 Column	
Component	B01.4.3.5.A.2 Shear Wall	
Component	B01.4.3.5.A.3 Slab	
Sub-element	B01.4.3.5.B Slab Work- Zone B	Zone
Component	B01.4.3.5.B.1 Column	
Component	B01.4.3.5.B.2 Shear Wall	
Component	B01.4.3.5.B.3 Slab	

Figure 1: Categorisation of a typical infrastructure project WBS, by Product and Location hierarchies.

### Problem analysis framework

Seventeen documents, including project work breakdown structure definition documents, various types of construction schedules (Gantt Charts) and other project management documents which described the project WBS, were reviewed from fourteen wide ranging projects or programs.

For three programs, there were two different views of the WBS: a program WBS chart and a program activity schedule based on a WBS. In these, there was at least one additional level of location required for the schedule WBS. Examination of the documents suggest that the rigour of scheduling requires additional location detail in the WBS.

Underlying this analysis is the knowledge that a WBS hierarchy, whether illustrated as a tree structure or a cascading list, has 1 code for each decomposition level. These codes can be linked in structural sequences to form an 'address' for each individual WBS element with the complete WBS:

X1.X2.X3.X4... Xn

Each lower WBS level extends the address to the right - until all 'n' levels are reached.

This research aims to categorise and model new breakdown hierarchies through three stages of analysis.

### First stage

The first stage of analysis categorises each level in the address by whether it describes a Product (what or how) or a Location (where) as shown in Figure 2 for a typical example.

In the analysis framework; P is used to denote both the process and the end product and L is used to denote either implicit or explicit location.

		Product	Location
B01	Building	P	L
4	Construction	P	
3	Super structure	P	
5	Fourth Floor Level		L
B	Zone		L
2	Shear Wall	P	

Figure 2: Categorisation of WBS level by Product and Location



No.	Project type	Document type	(1) Categorisation	(2) Coded	(3) PBS	(4) LBS	Note
1	Hospital Facility	WBS	P0.P1L1.P2L2.L3.L4.	C.D.D.L.L.	C.P.P.	L.L.L.L	
2a	Program Correctional Facility	WBS	P0.P1L1.P2L2.P3.L3.	C.D.D.P.L.	C.P.P.P.	L.L.L	
2b	Program Correctional Facility	Schedule	P0.P1L1.P2L2.P3.L3.L4.	C.D.D.P.L.L.	C.P.P.P.	L.L.L.L	
3	Plant building	WBS	P0.P1.P2L1.P3L2.	C.P.D.D.	C.P.P.P.	L.L	
4a	Hospital Program	WBS	P0.P1L1.P2.P3.L2.	C.D.P.P.L.	C.P.P.P.	L.L	
4b	Hospital Program	Schedule	P0.P1L1.P2L2.P3.L3.L4.	C.D.D.P.L.L.	C.P.P.P.	L.L.L.L	
5	Hospital Facility	WBS	P0.P1.P2L1.P3L2.	C.P.D.D.	C.P.P.P.	L.L	
6a	Recreational Program	WBS	P0.P1.P2.L1.	C.P.P.L.	C.P.P.	L	
6b	Recreational Program	Schedule	P0.P1.P2L1.L2.	C.P.D.L.	C.P.P	L.L	
7	Residential Facility	Schedule	P0.P1L1.P2.P3L2.L3.P4	C.D.P.D.L.P	C.P.P.P.P.	L.L.L	
8	Residential Facility	Schedule	P0.P1L1.	C.D.	C.P.	L	Schedule treats multi-level building as single location
9	Commercial high rise	Schedule	P0.P1.L1.	C.P.L.	C.P.	L	Limits breakdown to three levels, thus location is flexibly allocated
10	Residential Facility	Schedule	P0.P1L1.L2.P2.	C.D.L.P.	C.P.P.	L.L	
11	Residential Facility	Schedule	P0.P1L1.P2.L2	C.D.P.L.	C.P.P.	L.L	
12	Commercial high rise	Schedule	P0.P1L1.L2.	C.D.L.	C.P.	L.L	
13	Commercial high rise	Schedule	P0.P1.L1.P2.L2.	C.P.L.P.L.	C.P.P.	L.L	
14	Commercial high rise	Schedule	P0.P1.L1.	C.P.L.	C.P.	L	

Figure 3: Consolidated document analysis of 14 projects

Analysis showed that in order to completely describe each breakdown, it is necessary to allocate some WBS levels to both categories.

For ease of analysis, a tale was constructed showing generic WBS level descriptors in categories as either Product or Location (Figure 4).

The diversity in the sample documents included differences and even internal inconsistency in formatting, structure, and nomenclature. Project decomposition documents are not standardised because many global organisations have their own WBS style, commonly used software has built-in decomposition styles, and project managers develop their own methods based on experience.

Thus, some form of standardisation was required to be able to make comparisons across varying projects. For this framework, the highest extracted level is termed P0, and is defined as "Construction". In most cases "Construction" existed somewhere in the WBS and the analysis started at that level. Higher levels were then ignored. Where "Construction" was not specifically named in the project WBS, it was inferred.

All lower levels were allocated either a P ( $j=1,2,\dots,n$ ) or an L ( $i=1,2,\dots,n$ ) in rank order. In many cases the level was interpreted to describe both a Product and a Location. In this case, was allocated both P & L in accordance with the appropriate level in either type.

The Stage 1 result is shown in Figure 3: Column (1).

### Second stage

Any WBS or Project Schedule document can be analysed, in part or in full, using this simplified breakdown framework based on P & L notations. An example of two projects in Figure 4 indicates the common complexity in categorisation.

Complexity can be seen in the number of WBS line that use terms indicating specific locations as one way of defining a product. For example, in the first P1 (Product Type/Specific Location: Building A) and L1) Product Type/Specific Location: Building A) are the same and represent a single level in the WBS address. The dual nature of many of the WBS line items is the impetus for adding a Dual (D) notation.

The Stage 2 result is shown in Figure 3: Column (2).

Document Type	P0 Project Phase	P1 Product	P2 Product	L1 Location	L2 Location	Project Matrix Model
Project Schedule	Construction	Product Type/Specific Location: Building A	Element: Façade	Product Type/Specific Location: Building A	Specific Locations: levels 1-14	P0.P1L1.L2.P2.
Project Schedule	Construction	Element: Structure		Specific Locations: floors 1-14		P0.P1.L1.

Figure 4 Generic level descriptions for two projects



## Short-Form WBS

*An example of a typical matrix short-form WBS showing product (What and How) and locations (Where).*

Work Breakdown Structure		Location Breakdown Structure									
4 CONSTRUCTION		B01 RESI BLDG PROJECT									
4.3 Super Structure		B01.1 Ground Floor Level									
4.3.1 Slab Work		B01.1.1.A Zone A									
4.3.1.1 Column		B01.2 First Floor Level									
4.3.1.1.1 Column Rebar		B01.2.A Zone A									
4.3.1.1.2 Column Form Work		B01.3 Second Floor Level									
4.3.1.1.3 Column Concreting		B01.3.A Zone A									
4.3.1.2 Shear Wall		B01.3.B Zone B									
4.3.1.2.1 S'Wall Rebar		B01.4 Third Floor Level									
4.3.1.2.2 S'Wall Form Work		B01.4.A Zone A									
4.3.1.2.3 S'Wall Concreting		B01.4.B Zone B									
4.3.1.3 Slab											
4.3.1.3.1 Slab Form Work											
4.3.1.3.2 Slab Rebar											
4.3.1.3.3 Slab MEP Work											
4.3.1.3.4 Slab Concreting											

### Third stage

Question 1 asks: Is there empirical evidence from real world construction projects for repetition of WBS elements across locations?" Stage 3 of the research confirms that there is.

In columns 3 and 4 of Figure 3, the modelled project breakdown categorisation is further separated into the two categories of Product and Location. The relative position of the items in each breakdown corresponds with the position of the equivalent codes (P&D), L&D) in column 2.

Column 4 illustrates the significance of location to the project WBS and highlights the extent of repetition in WBS elements due repetition across locations. We can also say that every project has at least one level of subdivision of Location.

### Solution: A new short-form WBS

Given the empirical evidence for WBS element repetition driven by location, the secondary research question can now be addressed.

2. Could the matrix view of project decomposition be a useful mechanism for highlighting data repetition?

The conventional WBS can be viewed as a single dimension matrix for containing information about the project, such as the work effort required for delivery. However, we have now established that the individual elements in the array repeat due to the information being repeated across locations. Thus the conventional WBS is actually a long-form single dimensional matrix for data which has two dimensions. Consider the long-form as consisting of a list of product elements in a given location and then continuing on to another list for the next location, etc. until the final location has been reached. Logically it is more efficient to consider the WBS as the product of two dimensions, the Product breakdown (PBS) and the Location breakdown (LBS).

This important concept, considering the intersection of two differently focused breakdown structures, has received little attention by PM researchers. Yet this concept of the 2D model is a significantly different view of the WBS from the conventional definition of a hierarchical tree.

The key to changing the way we think about the management of projects is to change the way we decompose their structure. The problem with current practice is that the WBS is a single hierarchy structure which must meet conflicting demands.

It is recommended that work breakdown structures be designed to strip out location from the long-form hierarchy to create a Short-Form WBS.

### International standards

International open standards are increasingly important to Australian infrastructure. Transport authorities are interested in emerging models for data management that are influenced by location. Standards compliance is a significant part of their required contract documentation.

As this project progressed, the importance of international standards emerged as an important concern for the project steering committee. This research therefore aims to influence the development and enhancement of existing and new standards.

There are many standards and standards bodies which are relevant. The following are some significant stakeholders:

- ISO Standards for Project, Programme and Portfolio Management: Work Breakdown Structure (Committee Draft stage).
- buildingSMART is a network of linked groupings of software developers, universities, governments and product providers who have been creating publically available IT languages, frameworks and application directions. The development of the IFC (Industry Foundation Class); IFD (International Framework Dictionary) and IDM (Information Delivery Manual) are the necessary components of openBIM. IFC and IFC Infra include location definition models.
- The Open Geospatial Consortium (OGC) is an international industry consortium of companies, government agencies and universities which develops publicly available digital systems interface standards.
- ISO and AS/NZS provides the *Geographic Information—Linear Referencing* standard.
- Austroads is the Association of Australian and New Zealand Road Transport and Traffic Authorities. It serves as the Roads Modal Group of the Standing Committee on Transport. Austroads has a draft Data Standard for Road Management and Investment in Australia and New Zealand.

Looking forward, this research can be used to support these organisations in their new interest in the role of location. It is recommended that the research team engage with processes to revise/develop standards that involve location.



*Typical handover documents.*

## Lessons Learned from COBie and Handover...

The recommendation from SBEnrc Project 2.21, to reduce costs and improve asset management, was to consider lessons learned from COBie, an international standard, to establish a new CONie standard for horizontal infrastructure networks. The first step in this process is identify how these lessons relate to the asset life-cycle phase that is pivotal for both past and future information.

### The problem of handover: what a waste

One of the most significant sources of wasted effort in construction projects arises from the onerous task of producing documentation and product manuals. As such information is critical to the ongoing operation of infrastructure, companies allocate significant post construction resources to this task.

Evidence of the waste inherent in the handover process is obvious. Traditionally, most building owners have full-time data clerks to retype information from the paper documents into automated systems that support maintenance management.

Asset management information was traditionally specified as required at the end of the construction process. It was delivered to the facility operator prior to the fiscal completion of the project, generally in a manual reproduction of documents, as shown above.

This expensive process became embedded in virtually every construction contract in the industrialised world. And despite the fact that virtually the entire set of information could actually be traced to an electronic source.

### COBie has become the solution

COBie is an information exchange tool designed to transform construction handover documents into a set of **exclusively digital** information that is useful to an Asset Manager.

Capturing operations, maintenance, and asset management information from building projects is possible using the COBie standard (Construction to Operations for Building information exchange).

COBie is part of the United States National Building Information Modeling Standard: <http://www.nationalbimstandard.org/>.

In one decade, COBie has gone from a small ITC research project, to an internationally recognised, nationally mandated, performance-based contract specification.

The developer of COBie, Bill East, assisted the research team. Thus Project 2.33 has the benefit of a researcher with practical experience in developing elegant solutions for the very practical problem of excessive administrative waste for building construction handover.

Today, in the building construction sector, the practice of facility operations and maintenance is in the first stages of transforming handover from a document-centric to an information rich practice based on COBie.

The COBie standard smoothly merges building asset information by defining:

1. the specific set of managed assets
2. the assets located in a building
3. the asset information needed to insure proper maintenance
4. the common classification.

Essential to the specification of COBie is the recognition that maintenance managers do not require the same level of detail needed by both designers and builders.

Once the building is built, the design level of detail is typically not required. When maintenance checks equipment operation, the only accuracy of detail required is that of a location reference. Knowing where the room that houses the equipment is located is more important to maintenance than knowing the exact coordinates.

In fact, maintenance will be likely to ignore detailed 3D models unless equipment is being entirely replaced.

## ... for Developing CONie:

# Construction to Operations for Network information exchange

### Changing how information is exchanged

COBie has become a successfully implemented standard. It is now an internationally recognised, performance based, contract specification. Frequently used in major infrastructure projects, it is also nationally mandated in the UK and Singapore for public works.

In part, this success is because the quality of the information used in the specification was identified as a priority for the development of COBie. Focus on quality data is a necessary feature of the transformation process from document-centric to information-centric construction deliverables for operations.

Automated CONie testing tools should be developed to evaluate the format and referential integrity of data provided. Importantly, the evaluation, to check the quality of the CONie data, is based on the understanding that objective criteria are necessary.

For example, the information currently presented on original design and construction documentation will need to match the information in the CONie presentation of that information.

A significant feature of a successful standard is how it can distinguish between commonly used information and discipline- or trade-specific information. Common information will typically relate to the overall physicality and gross measurements. Beyond that, little of the specific information that makes disciplines or trades unique will be of interest outside their designated spheres of endeavour. It is important to enable multiplicity of use.

COBie benefited from the location-definition model inherited from the buildingSMART Industry Foundation Classes (IFC). While this simple model suited the design perspective of vertical infrastructure, it does not suit the design perspective of horizontal infrastructure that requires linear and network structures. A new location definition model is therefore required.

### CONie: an information exchange for road network asset management

The proposed CONie will provide contract methods, mandating the use of a connected digital repository (such as an SQL database) constructed to a standard specification, and suitable for automated input into redesigned compatible operations management systems. The new CONie should:

- be perceived as an open standard for hand-over to facilitate the transfer of information from traditional documents to structured digital information.
- not change the actual information currently delivered, but rather ensure long-term survival of road network construction information in an easily retrievable format.
- transform the way that information is to be delivered.
- support a standardised information data format.
- provide a performance-based specification for project information delivery.

Much of the design and construction data needed by specific domains (such as pavements, signage or geometrics) may be redundant, and clearly all information selection and representation should be modelled consistently across domains.

For CONie to be successful, it must model the details of each part of the road infrastructure network in ways that professionals and practitioners clearly understand. Asset Managers, Operations Systems, Maintenance Work Orders, and New Capital Works will all depend on accurate and usable information to provide the best service for all road network stakeholders.

The CONie network location definition model must incorporate asset owners requirements, such as the needs of multiple road authorities whose current asset management systems vary widely as do their current location referencing systems.

# Importance of Location in Development of CONie

In designing CONie, information must refer to location through a location definition model. Attention must be paid to the needs of multiple disciplines because the end-users will have different requirements. Current methods for location referencing found in COBie are inappropriate for infrastructure networks.

---

## Further work required for location definition models

The specific problem related to the data used and the information transferred is that COBie has a simple model for location that strips out the local (model-limited) geometric coordinate information from the IFC (buildingSMART open standard) data. However, the service needs for asset management of horizontal infrastructure requires more location information to be retained. This can be accomplished by developing a more comprehensive approach to location-breakdown for horizontal infrastructure.

The “real world” coordinates that prevail in horizontal infrastructure design and construction are currently standardised using the Geocentric Datum of Australia (GDA) coordinate system because network asset management requires more flexibility. Every object has a location, whether it is on the earth, in the air or underground. Every location can be defined in terms of latitude, longitude and height (usually taken with reference to mean sea level or the geoid). The geoid represents the shape of the earth without features and is known to be approximately a squashed sphere.

The problem for road network management is that multiple location standards are used. Coordinate information may resolve to millimetre accurate GDA coordinates or to less accurate GIS systems. Frequently, “rubber-banding” techniques are required to align location data from several sources.

Furthermore, accurate road location information and data is necessary for supporting two functions: service provision and physical network asset management. Again, knowledge can be transferred from another discipline in the form of lessons learned. Corporate Real Estate Asset Management (CREAM) concepts and methods can be applied to road network Asset Management. CREAM has experience in distinguishing between data use for

the physical asset from the data use for the service provision the asset will be called upon to deliver.

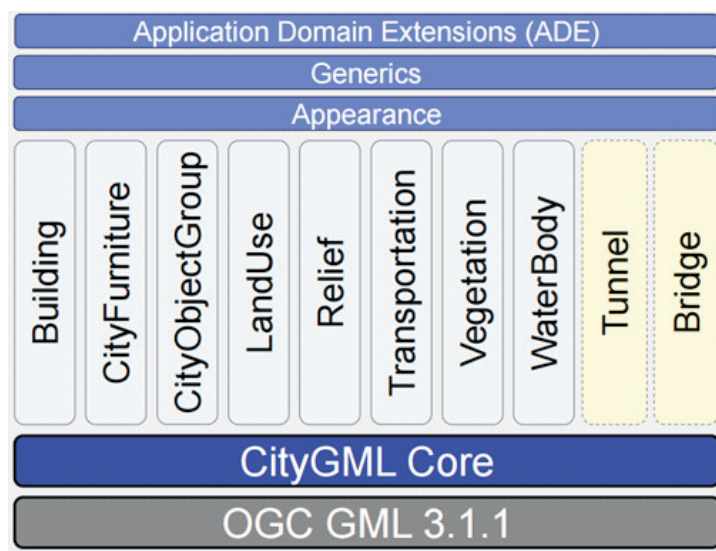
Current open standards initiatives for horizontal infrastructure are focused on design. IFC-Alignment including: IFC-Road Design, IFC-Bridge Design, IFC Shield Tunnel Modelling have been heavily influenced by the vertical BIM concepts. While this is a healthy first step, it is desirable that owners of horizontal infrastructure intervene to ensure relevance of outcomes.

The location model is a foundation concept that, once set, determines all subsequent systems. Locations are a network of interconnected continuous lines and intersections poorly suited to a hierarchical arrangement. It is critical that a suitable location-model is identified and supported to ensure that standards also include construction and asset management requirements. CONie is only one such system.

Location is again important for service performance of an operating network. Coordinate information for locations does not convey meaning except through computer-based systems. For this reason road authorities hold to their established location referencing systems.

It is recommended that further research into location definition models for roads and transport networks be undertaken, with an emphasis on multiple perspectives of the network purpose.





## Engaging with International Standards

It is recommended that further research design and develop a CONie. This concerns standards and a focus on International Standards is recommended. One outcome of SBEnrc Project 2.33 was a submission for additional funding to design CONie.

### The importance of international standards

As noted earlier, international open standards are increasingly important to Australian Infrastructure and transport authorities.

There are many relevant international standards and many jurisdictions (across the world) developing their own versions of standards. Again, it is important to engage in these processes and to influence the how and which international standards emerge to influence implementation.

The project also aligns with an Austroads' priority: Cross Asset Optimisation. The Asset Management ISO 5500 Standard series require an holistic approach to allocating funding across asset classes. This will optimise road asset performance. Such a requirement demands asset data interoperability between organisations and across assets. This will be assisted by a common standard for information exchange (CONie).

Therefore, it is recommended that further research be undertaken to develop a functional CONie. This will design a new system: CONie to solve the information bottleneck for roads. This innovation learns from the development process experienced by an established information exchange standard (COBie).

The proposed research will be at the leading edge of information management for horizontal infrastructure. This innovation requires new knowledge:

- A new model for physical location that aligns construction operations with road asset management.
- A new model for service location that provides for road service performance management.
- A new model based on a proxy for "object" definition of assets for a road information exchange.

It is recommended to pursue the CONie specification: A new suite of open standards and methods for implementing, testing, and enforcing the delivery of road construction information to operations handover.

### An ARC Linkage project: LP160100524

An application for Australian Research Council (ARC) industry supported funding for CONie has been successful. The project project will continue the SBEnrc connection with CONie through the support of its Core Members:

- **Roads and Maritime Services NSW**
- **Main Roads WA**
- **Aurecon**

The project is also supported by **New Zealand Transit Authority**.

The interdisciplinary project team includes members from:

- **Swinburne University of Technology** (Administering Organisation),
- **Curtin University of Technology**
- **Queensland University of Technology**
- **University of Melbourne**

The project team was selected not only by their technical and domain knowledge, but also by their ability to influence relevant international standards. Four international standards are targeted:

- Industry Foundation Classes (IFC) are the neutral data format for openBIM. IFC4 is accepted as ISO-16739 standard.
- CityGML from the extendible international standard for spatial data exchange issued by the Open Geospatial Consortium (OGC) and ISO-TC211
- Project Programme and Portfolio Management (ISO-21500) is the family of standards relating to generic management strategies.
- The Asset Management standard (ISO-5500).

The project investment is \$349,000 (ARC) and \$310,000 (Industry) plus in-kind participation from all participants.

# Australian Sustainable Built Environment National Research Centre

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

---

The SBEnc 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 SBEnc activities are realised through national, industry and firm-level competitive advantages; market premiums through engagement in the collaborative research and development process; and early adoption of Centre outputs.

The Centre integrates research across the environmental, social and economic sustainability areas in programs respectively titled Greening the Built Environment; People, Processes and Procurement; and Driving Productivity through Innovation.

Among the SBEnc'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.

Essential to SBEnc achieving its goals is this core project: *Location Importance in Infrastructure: New Project Management Structures*.



**Professor Keith D Hampson**

Chief Executive Officer  
Sustainable Built Environment National Research Centre



**Professor Russell Kenley**

Project Leader  
Sustainable Built Environment National Research Centre



## Project references

Kenley, R & Harfield, T (2016) *Location Importance in Infrastructure: New Project Management Structures*. Sustainable Built Environment National Research Centre (SBEnrc), Perth.

---

For more detailed information about this research please refer to the Position Papers available at [www.sbenrc.com.au](http://www.sbenrc.com.au) (Project 2.33):

1. East, B, Kenley, R & Harfield, T (2015) *CONie: Lessons Learned from COBie Specifications and Standards*. Briefing Paper, Project 2.33 New project management structures. Sustainable Built Environment National Research Centre (SBEnrc), Perth.
2. Kenley, R & Harfield, T (2015) *Project Management Intervention: LBS/WBS Influencing ISO Project Standards*. Position Paper 1, Project 2.33 New project management structures. Sustainable Built Environment National Research Centre (SBEnrc), Perth.
3. East, B, Kenley, R & Harfield (2015) *Network Asset Intervention: Designing CONie*. Position Paper 2, Project 2.33 New project management structures. Sustainable Built Environment National Research Centre (SBEnrc), Perth.

This research would not have been possible without the ongoing support of our industry, government and research partners:

## SBEnc Core Partners



## Project Partners



For further information:  
Professor Russell Kenley: Program and Project Leader  
Swinburne University of Technology  
[rkenley@swin.edu.au](mailto:rkenley@swin.edu.au)

Dr Toby Harfield: Research Associate  
Swinburne University of Technology  
[tharfield@swin.edu.au](mailto:tharfield@swin.edu.au)

[www.sbenrc.com.au](http://www.sbenrc.com.au)

December 2016

