Coordination and Collaboration of Information for Pan Borneo Highway (Sarawak) via Common Data Environment (CDE)

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Abstract. Development of the Pan Borneo Highway in the Malaysian state of Sarawak is the single largest infrastructure project ever undertaken in Malaysia’s largest state. Construction works over 786km across Sarawak are underway today in 25 sections at 11 works packages. With multiple disciplinary teams working concurrently, housed in different locations including at remote construction site offices, the efficient management of up-to-date data based on a single source of truth is important for effective decision-making. There can be no compromise in the quality of input at all stages of construction. As Project Delivery Partner, Lebuhraya Borneo Utara (LBU), leverages on technology to improve project management - from planning and design, to construction and monitoring, and preparing to operate and maintain the final asset. The task is challenging at best. To meet its needs for coordination and collaboration of various information sources, LBU uses a Common Data Environment (CDE) to enable teams to work together on the same information. Such information is monitored, tracked and validates, leading to an overall improved efficiency and productivity, and reduced risks. The CDE is central to LBU’s Project Information Management System and Highway Information Modelling, key components for project delivery of the Pan Borneo Highway Sarawak within time and cost.

1. Introduction

Implementation of a Common or Connected Data Environment CDE has been recommended by many international institutions and authorities. According to the PAS 1192-2:2013 Incorporating Corrigendum No. 1 specification for information management for the capital/delivery phase of construction projects using BIM from the BSI, the CDE is a means of providing a collaborative environment for sharing work. It can be implemented in a number of ways. BS 11000-1 and -2 [1] describes the development of various forms of collaboration within organisations and across project teams.

Implementation of CDE for infrastructure projects, especially mega infrastructure projects, has been adopted here in Malaysia. A successful example is the implementation of the MRT Line 2 project. Using a CDE, MRT Corp as project operator of MRT Line 2 (SSP Line) project, was able to implement BIM standards and strategies, including digital workflows, improve design collaboration and coordination, construction feasibility, and accuracy of as-built information for the underground work on the SSP line [2] across the Klang Valley.

More recently, a CDE implementation with a similar systems approach utilizing Bentley’s ProjectWise has been adopted for development and upgrading of the Pan Borneo Highway in the state of Sarawak. Development of this large-scale infrastructure project has required a holistic and integrated system to be used by its Project Delivery Partner, Lebuhraya Borneo Utara (LBU), for all phases of
construction to maintenance. Today, implementation of a CDE is used by LBU to support an Integrated Project Management System (IPMS) framework.

2. Study Area and Scope

The long-awaited Pan Borneo Highway in the Malaysian state of Sarawak on the island of Borneo will span an estimated 1,060 km. Works are on-going to develop and upgrade the current 2-lane single carriageway which connects the entire state into a 4-lane dual carriageway. The project is being undertaken by the Government of Malaysia and State Government of Sarawak through a Project Delivery Partner (PDP). For this, a special purpose vehicle private entity, Lebuhraya Borneo Utara (LBU), has been appointed as the PDP.

Costing RM16.5 billion, Pan Borneo Highway Sarawak is deemed to be the single largest infrastructure project ever awarded by the Government in Sarawak. Implementation of the project involves construction of 786 km of a new 4-lane highway in 11 works packages. Works began in January 2016, with the Highway targeted for completion in 2021. Operations and maintenance of the Highway will follow upon completion of construction.

As PDP, LBU is in charge of the entire project lifecycle, from planning to design and construction, to operations and maintenance of the completed highway. As PDP to the Government, LBU is committed to deliver the project on time and within budget. An associated company will then undertake operations and maintenance of the highway.

In managing the delivery of a project of such scale, LBU anticipated several challenges in communicating, monitoring and managing project progress to ensure the project will be completed within the expected timeline and cost. Challenges include:

- Consolidating project information created at various locations by various parties throughout the project lifecycle.
- Managing project information and document flows that ensures the information can be leveraged throughout the entire project lifecycle.
- Providing visibility of project progress and insight to key stakeholders.
- Enforcing standards across the entire project operation, audit trails, and control of access and use of information.
- Progress reporting across various disciplines.

A project of such scale and magnitude requires the capabilities of a CDE to be in place to support numerous Bentley suite of products that is used throughout the project’s lifecycle - from design to construction to operation. This ensures a timely and cost-effective project delivery and overall efficient management of a key Government asset.

3. Common Data Environment within LBU’s Integrated Project Management System (IPMS)

3.1 Common Data Environment

A Common Data Environment (CDE) acts as a central repository where construction project information is housed. Contents of the CDE are not limited to assets created in a ‘BIM environment’. The CDE includes documentation, graphical modelling and non-graphical assets [3]. By using a single source of information, collaboration between project members can be enhanced, mistakes reduced and duplication avoided [3]. A typical lifecycle of a project using a CDE is depicted in Figure 1.
Project management of the Pan Borneo Highway Sarawak requires an increasing number of systems as the project progresses towards completion. With numerous systems, there is a need to have an end-to-end solution, such as a CDE, for project documentation and management which acts as a single platform, ready to incorporate the Highway Information Modelling (HIM) and Asset Management/Maintenance systems.

LBU decided to adopt a CDE which can be a repository of all information created. Not merely a simple document storage, its CDE is a platform which can store documents per the BS 1192 (BIM) standards, coupled with functionalities for workflows built-in for sharing and managing changes with dependency management. A CDE has helped LBU to implement BIM, from managing the 3D design information created by consultants, to construction, through to linking this information with asset tags to develop the highway’s future asset management solution. This fulfills the BIM implementation requirements of the organization. In general, a CDE enables LBU to:

- Read and consolidate information generated in different formats
- Structure and manage information created at distributed locations
- Enforce work flows and standards
- Generate audit trails and enforce controls
- Provide progress dashboards to all stakeholders
- Form an information platform as a foundation for the asset lifecycle management

3.2 LBU’s Integrated Project Management System (IPMS)

LBU incorporates an Integrated Project Management System (IPMS) as a systems management roadmap which will be implemented throughout the entire project lifecycle. The IPMS is based on a technology advancement strategy and execution plan which assist LBU to monitor and provide controls for the project.
The IPMS is expected to be implemented across all phases of the Pan Borneo Highway Sarawak project. Therefore, adoption of a common systems approach is essentially important to ensure continuous effort, results and improvement.

A similar systems approach utilizing a Bentley platform has been adopted to establish a holistic and integrated system implementation under LBU for all phases.

**Figure 2.** Conceptual solution framework diagram of an end-to-end system of the IPMS.

**Figure 3.** High-level system architecture of IPMS Phase 1A.

Based on the existing systems platform framework, the CDE platform ProjectWise supports two sub-systems, namely:

1. The Project Information Management System (PIMS); and
2. The Highway Information Modelling (HIM) system which is an integration of Building Information Modelling (BIM) and Geographical Information Systems (GIS).
The Highway Information Modelling (HIM) developed for Pan Borneo Highway Sarawak was constructed using Autodesk modelling applications, namely Autodesk Civil 3D and Autodesk Revit in the IPMS Phase 1A implementation.

The 3D models were geo-referenced using airborne LiDAR data, enabling it to have location (x and y) and height accuracy (z). Using extracted GIS features from the LiDAR data, modellers were able to have greater visibility on the existing environment surrounding the highway design. This helped the modellers conduct analysis and produce more accurate 3D models.

The HIM is useful for the construction phase. As Project Delivery Partner for the Government, LBU’s ultimate goal is to evolve the models into the as-built phase of the highway where these models are expected to be used for the highway’s operation and maintenance. Hence, all the models will be unified on the CDE platform for further integration with Pan Borneo Highway Sarawak’s Road Asset Management System (RAMS).

Learning from implementation of Phase 1A, LBU observed that the intra-operability of the BIM modelling applications is an important element to the success of the cohesive implementation of IPMS. The models developed in individual modelling applications must be intra-operable with other modelling applications in order to create a federated modelling approach. This allows for better modelling coordination and integration with CDE and RAMS.

As a user, it is LBU’s preference to use modelling applications that support a federated modelling approach for future phases of the highway project. Examples of identified solutions are Bentley OpenRoads, Bentley Open Bridge Modeller and Bentley AECOSim.

4. LBU Project Information Management System (PIMS) Implementation with Bentley’s ProjectWise

LBU has identified a Project Information Management System (PIMS) designed to connect people and information across project teams no matter where they are located. The PIMS not only helps companies manage their documents, but also facilitates workflows, auditing and application integration from design to construction to asset management per BS1192 standards while improving quality, reducing rework, and helping project teams meet their deadlines.

Technically, Bentley’s ProjectWise solution includes an integrated suite of desktop and server software for content management, content publishing and design review to uniquely address project needs of all connected stakeholders.

It has built-in BS 1192 folder structures, workflows for information-sharing and management, capabilities to share drawings for construction, and manage change / issue process with seamless links to source documents. With Bentley’s ProjectWise, the PIMS meets the objectives in table 1.

The PIMS implementation is conducted based on industry practices of systems implementation. A waterfall methodology had been leveraged with several important milestones of the project, such as endorsement of the User Requirement Documentation by Key Users, User Acceptance Test (UAT), and others at each phase of the PIMS development to ensure the system is implemented as expected.
Table 1: PIMS implementation objectives.

| IMPROVE PROJECT DELIVERY | • Improve data sharing through all project phases  
|                          | • Better coordination among owner – consultant - contractor teams  
|                          | • Produce digital plan and models through all phases  
| OPTIMIZE EFFICIENCY      | • Reduce project delivery time and improve quality  
|                          | • Reduce cost while improving productivity  
|                          | • Accurate costing and reduced risk  
| CREATE BUILDING INFORMATION MODELS FOR BETTER ASSET MANAGEMENT | • Leverage on the technology platform to create & use information on the asset for better Asset Maintenance  
| DEVELOP LOCAL ENGINEERING INDUSTRY SKILLS | • Train local teams involved in the project about world-class design & construction processes  

Figure 4: Phases of PIMS Implementation.

Today, a total of 74 business processes within LBU, have been incorporated into the PIMS.

These business processes involve interaction and communication between inter and intra-departments within LBU, between head office and site offices, and among the project communities which involves works package contractors (WPCs), regional engineers (REs), consultants and others. In addition, interaction and input is extended to external stakeholders, such as the project owners, i.e. relevant Government agencies.

The CDE allows project information and business processes to be incorporated into digital workflows conducted in the PIMS.
In short, a CDE, provisioned for the owner as a cloud service, now captures and intelligently shares all digital workflows, enabling participants to automate their collaboration protocols as if they were one project enterprise [4]. This capability is important for project management of the highway.
With project information being developed in the PIMS, it becomes a single source of information for the whole project. Information is coordinated centrally and verified before the other team members can use it within their own environment.

One of the key benefits of having centralized project information in a digital format throughout the digital workflows is the ability to extract desirable and relevant pieces of information for display. An example is summarizing project progress into project dashboards for reporting. These project dashboards provide detailed insight to the project communities to enable better monitoring and management of project progress, and ultimately better decision-making.
Figure 9. An example of a Project Operational Dashboard interface on Quality Assurance & Quality Control.

Figure 10: Example of Project Operational Dashboard Interface on Bumiputera participation.

5. Conclusion
The Common Data Environment (CDE) offers the opportunity to effectively and efficiently coordinate and collaborate various project management systems throughout the project’s entire lifecycle under a single platform. This capability is important to manage, monitor, maintain and control, especially in a large infrastructure project spread out in different locations, with a myriad of processes involved from design to construction management, document management and cost control, until asset management.
In the case of the development of the Pan Borneo Highway Sarawak, CDE’s key offerings include providing enterprise-level engineering content management for geographically distributed project teams, construction and contracts management, business intelligence, insight for asset-tagging and seamless integration with engineering and other desktop applications.

A CDE implementation for infrastructure projects provides measurable Returns on Investment (ROI), such as saving time in finding, validating and accessing project information. The CDE reduces project risks with a single source of truth for all project information, improves quality and consistency of all project deliverables, avoids late delivery penalties, reduces last minute rework, maximizes workforce utilization, shares work across multiple offices, and helps meet project deadlines.

In summary, a CDE is an important foundation for the coordination and collaboration of rich information and data for large scale infrastructure projects, such as the implementation of the Pan Borneo Highway Sarawak project until the operations and maintenance of the highway asset.

6. References

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