



ELSEVIER

Contents lists available at ScienceDirect

Automation in Construction

journal homepage: www.elsevier.com/locate/autcon

Civil Integrated Management: Empirical study of digital practices in highway project delivery and asset management

Bharathwaj Sankaran^a, Guillermo Nevett^b, William J. O'Brien^{a,*}, Paul M. Goodrum^b, Joshua Johnson^b

^a Department of Civil, Architectural, and Environmental Engineering, The University of Texas at Austin, 301 E. Dean Keeton Street, ECJ 5.412, Austin, TX 78712-1094, United States

^b Department of Civil, Environmental, and Architectural Engineering, The University of Colorado at Boulder, Boulder, CO 80309-0428, United States

ARTICLE INFO

Keywords:

Civil integrated management
Information modeling
Highway infrastructure
Digital workflow
Project delivery
Asset management
BIM for infrastructure

ABSTRACT

Principal technologies and practices contributing to the workflow of highway infrastructure projects are undergoing significant changes due to Civil Integrated Management (CIM). CIM encapsulates key digital technologies that provide managers with opportunities to use accurate data and information throughout the life cycle of a transportation asset. Despite the potential of CIM tools, the extent to which State Transportation Agencies (STAs) across the U.S. make use of CIM and the factors enhancing the utilization of CIM have not been studied sufficiently. This paper presents the principal findings of a national survey of forty-two STAs on CIM usage. Results show that while thirty-two STAs use the CIM tool of 3D design for terrain modeling, only sixteen reported using it for structures and advanced visualization. The research also analyzed the influence of key agency policies such as contract specifications, project delivery methods, and STA budget on the use of CIM. While the budget does not have a statistically significant effect on increased CIM usage, results indicate contract specifications and various procedural guidelines for CIM do affect CIM usage. STAs also appear to use CIM more when they have alternative delivery methods available, with a statistically significant positive impact being shown by the Public-Private Partnerships model. This study provides both a benchmark of current practices as well as suggestions that may expedite beneficial implementation and future research in this area.

1. Introduction

Civil Integrated Management (CIM) has been promoted as a path to improving project outcomes for stakeholders on transportation projects [1]. “Civil integrated management (CIM) is a term that has come to be applied to an assortment of practices and tools entailing collection, organization, and management of information in digital formats about a highway construction project” [2]. CIM shares many attributes with implementing Building Information Modeling (BIM) for highway projects but has its own definition in large part due to the unique aspects of infrastructure projects. These include expansive horizontal elements, associated right-of-way (ROW) acquisition, utility coordination, environmental challenges, and expanded stakeholder input [3,4]. It also entails a broader scope than BIM, inclusive of connected technologies and practices that can enable a data-centric and digital workflow for highway project delivery and asset management. These include advanced surveying methods, model-based design processes and project management, automated machine control for construction, and digital

archival for asset management [2]. CIM adoption has also gained considerable significance and traction in the international context, particularly in large infrastructure projects such as Crossrail Ltd. - £14.8 Billion UK Metrorail project that has gained recognition for its lifecycle implementation of information modeling practices and related digital technologies [5].

A central factor in the adoption of CIM is the public agencies that sponsor projects. While acting as the client or owner on behalf of the public, policies of the agency can greatly influence adoptions of CIM practices. In the US context, major transportation projects are primarily administered by State Transportation Agencies (STAs). STAs adopt CIM in hopes of improving project cost, schedule, and quality. Many STAs, however, apply CIM practices only at specific phases of projects; it is still a goal for many STAs to implement these practices across an asset's lifecycle [6]. There is limited research in the literature to either empirically assess the state of practice of CIM across STAs or to outline managerial and policy issues influencing an agency's capability to implement CIM. Using a national survey of STAs, this paper quantitatively

* Corresponding author.

E-mail addresses: bharathwajs@utexas.edu (B. Sankaran), guillermo.nevett@colorado.edu (G. Nevett), wjob@mail.utexas.edu (W.J. O'Brien), Paul.Goodrum@colorado.edu (P.M. Goodrum), Joshua.F.Johnson@colorado.edu (J. Johnson).

<https://doi.org/10.1016/j.autcon.2017.12.006>

Received 20 February 2017; Received in revised form 29 October 2017; Accepted 6 December 2017

0926-5805/ © 2017 Published by Elsevier B.V.

gauges the state of CIM practice, eliciting related organizational considerations through hypothesis testing and inferential statistical analyses. Concisely put, this study provides both a benchmark of current practices and outlines agency policies that enhance CIM usage. As such, the results and insights from this study provide guidance for both practitioners and researchers in the highway industry.

The rest of the paper is organized as follows. The background review section synthesizes the key CIM technologies and explains their contribution towards a digital workflow. The following section presents research objectives and methodology. The next section presents descriptive statistics of the survey results followed by hypothesis testing on selected managerial and policy issues. Finally, the paper summarizes the significance of the statistical findings with notable examples from both national practices and the Crossrail project.

2. Background review of CIM

The significance of CIM practices is reinforced by its inclusion in the strategic Every Day Counts-2 (EDC-2) initiative—a state-based model coordinated by Federal Highway Administration (FHWA) and American Association of State Highway Transportation Officials (AASHTO). EDC-2 ascertained and promoted proven emerging technologies and innovative practices for highway project delivery [7]. In doing so, the initiative facilitated dissemination of procedural guidelines, workshops, training programs, and best practices focusing on advancements in highway design and construction technologies. CIM was included in EDC-2 as a formal recognition of the systemic interdependencies and shared implementation benefits and challenges of the several digital technologies across the asset lifecycle. As such, CIM aims at defining and aligning the highway project workflow to adapt to the modern technologies that have penetrated both the office environments (planning and design phases) and field activities (construction, operations, and maintenance). This section elaborates on the constituents of the digital workflow, from surveying to operations and maintenance, and the transition it creates in the project delivery process.

During project development and scoping phases, project managers' decision-making processes are significantly facilitated by having access to accurate geospatial data. Well-compiled and integrated data sources, besides enhancing the reliability of the impact assessments and alternative analysis, can inform the surveying needs for new construction or maintenance works [8]. The data on existing conditions can be augmented with advanced surveying methods such as; Mobile Light Detection and Ranging (LiDAR), Unmanned Aerial Vehicles (UAVs), digital photography, and photogrammetry. These methods provide semantically rich, digital information—such as point clouds, 3D mesh

models, high-resolution images, and Digital Terrain Models (DTMs). In fact, researchers have identified Mobile LiDAR and UAVs as being important tools with applications across the lifecycle of a highway facility ranging from topographic mapping, general measurements, the 3D design of alternatives, clash detection, as-built surveys, and inventory mapping [9].

Having good quality survey data helps designers in all disciplines work in a 3D environment and produce digital deliverables. The uncertainties related to utility relocation and coordination can be reduced through planned applications of various Subsurface Utility Engineering (SUE) tools on projects; such applications also produce geospatial 3D data that can be integrated during design [10]. The model-based design also plays a vital role in producing information that can be directly leveraged for design coordination, clash detection, and scheduling construction activities. 4D modeling and advanced scheduling practices have demonstrated the potential benefits to be gained in managing and resolving uncertainties associated with engineering deliverables for construction, on-site materials management, and labor productivity issues [11].

The quality and completeness of the model-based design positively affect the potential to transform the data into machine-readable formats (such as eXtensible Markup Language (XML)). The contractors can use this data along with sophisticated positioning systems (e.g. Real Time Network (RTN)) to automate field construction activities such as excavation, grading, milling, paving, and construction of curbs and retaining walls [12]. Pavement operations for asphalt and concrete slip-form paving generally require augmentation of vertical accuracy for machine control. Robotic Total Stations (RTS) are commonly used for this purpose [13]. Automated Machine Guidance (AMG) for on-field construction has proven to be beneficial as it improves productivity, provides better Quality Control (QC) for pavements and structures, and enhances the safety records onsite [14]. Another CIM practice is Intelligent Compaction (IC) of soils and pavement materials. IC encompasses computer, measurement, and control systems that digitally capture the compaction parameters and dynamically adjust the operation [15]. Recent advancements in automated construction have also enabled the use of 3D data in retaining wall construction and the construction staking of other structural elements [16]. After construction, the as-built data can be updated for a digital archive of information to facilitate asset management and future project development. Agencies and consultants have used digitally encrypted electronic signatures to expedite review and approval processes and enhance the overall quality of information flow [17]. Fig. 1 depicts the lifecycle adoption of the key digital technologies reviewed here and highlights the transforming practices relevant to CIM.

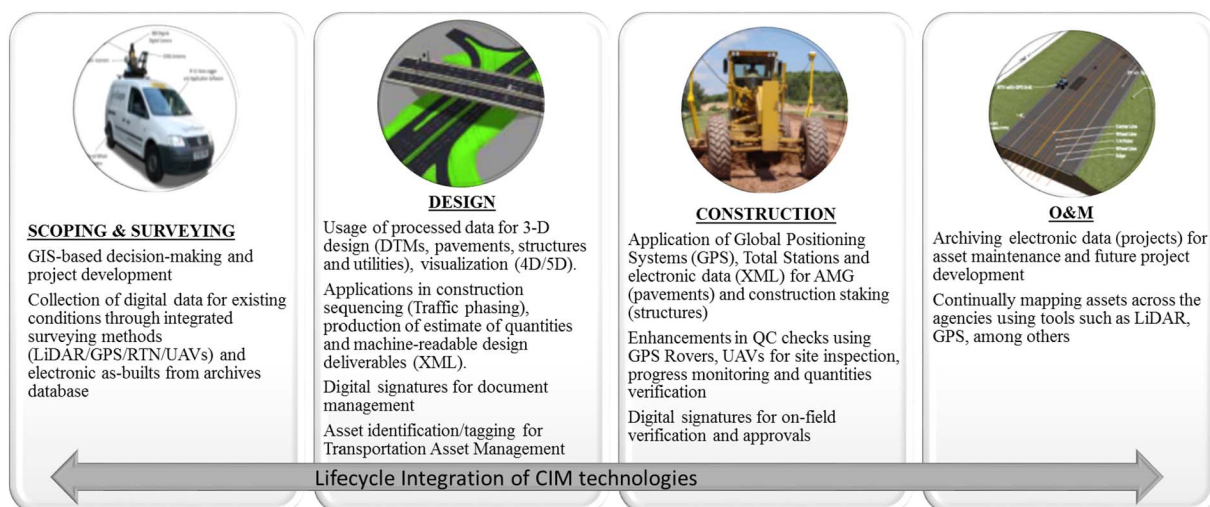


Fig. 1. CIM integration for asset lifecycle.

Download English Version:

<https://daneshyari.com/en/article/6695856>

Download Persian Version:

<https://daneshyari.com/article/6695856>

[Daneshyari.com](https://daneshyari.com)