Life cycle management of construction projects based on Virtual Prototyping technology

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Abstract: Life Cycle Management (LCM) has been waged in the management of constructio nprojects for many years in order to abate whole life cost, time, risk and improve the service to owners. However, unpaid to lack of an sucessful information sharing platform, the current LCM ofconstruction projects is not effectively used in the construction industry.
Based upon the analysis ofthe information flow of LCM, a Virtual Prototyping (VP)-based communication and collaborationinformation platform is proposed. Following this, the way is modified using DASSAULT software. The whole process of appliance the VP-based LCM of projects is analyzed via the application to a real life construction . The advantages of implementing a VP-based LCM arealso talked and, from a simple case study, it is demonstrated that the VP-based communicationand collaboration information platform is an effective tool to support the LCM of construction projects.

Keywords: Construction projects; Life cycle management; data sharing ; Virtual prototyping

Introduction

Life Cycle Management (LCM) has been introduced into the administrator of construction projects inrecent years (Gransberg and Ellicott 1997; Jaafari 2000) and it is accepted that LCM can slow the life-cycle cost of projects and improve the service to owners (Chalfant 2001; by Xie and Simon 2006).Construction project management is traditionally separated into several independent and bordering phases, e.g. planning, design, construction, commissioning, etc, and they are implemented respectively with almost no communication orinteraction between participants in each phase by Gransberg and Ellicott 1997. This may gone to many problems. For example, due to lack ofcommunication and collaboration between designers and constructors, most of designs need to bemodified or reworked during construction due to its unfeasibility; otherwise, these changes cannot beeffectively supported by design personnel in that after a design is finished and then transferred toconstructors, design personnel's tasks are over in the traditional project management method.

As a result, time or cost overruns often occur and the rights (e.g. normal completion time, cost, etc) of owners are unable to be warranted (Ellicott 1994).The application of the LCM approach helps to solve these problems. LCM integrates each phase of project management from planning to close-out, making information sharing and coordinationpossible between owners, consultants, designers, contractors, etc (ISO 2002; Teresko 2004). Allparties can communicate and collaborate with each other in real-time. On the one hand, this makesthe holistic operation processes consistent so as to ensure a reasonable construction time and cost; onthe other hand, it enables the owners' interests to be protected due to their ideas receiving due attention form the parties involved.

As differenty , this paper describes the use of Virtual Prototyping (VP) for the LCM of construction projects. VP technology is a computer-aided design process concerned with the construction of a digital mock-up and practical graphical simulation to address the broad issues ofphysical layout, operational concept, functional specifications and dynamics analysis under variousvirtual operating environments (Shen et al. 2005; Xiang et al. 2004; Pratt 1995). Although VPtechnology has been extensively and successfully applied to the automobile and aerospace fields(Choi and Chan 2004), its growth and application in the construction industry (i.e. constructionprocess simulation) has been limited to date. This is due to construction projects being uniqueinterms of their conditions, requirements, and constraints. The Construction Virtual PrototypingLaboratory (CVPL) of the Hong Kong Polytechnic University has manage much research into the employment of VP to real-life construction projects in Hong Kong, e.g. (Huang et al. 2007). Thishas shown VP technology to be a useful tool and effective viuable communication

and association platform for owners, consultants, designers, contractors, subcontractors or other participants in thedesign, construction and management of construction projects.Based upon CVPL research, the VP technology is showed as a key technique to establishing avisual communication and associated information platform for the LCM of construction projects. Its theoretical structure is elaborated and the implementation process of VP based LCM is examined into down a real-life construction project in Hong Kong - the TseungKwan O (TKO) Sports Ground.

The information flow of LCM of construction projects

Process of implementing VP-based LCM

Planning

At the beginning of the planning phase of a construction project, the LCM can be tool through the VP-based information platform. The owners describe their ideas of the construction project, the consultant/designer can easily communicate with owners and quickly and accurately get their opinions on the basis of the information platform. Also many ideas can be easily tried with a very low cost using VP technology until a best ideas is created. As an example ,Figure 6 shows the final arrangement of the TKO sports ground project in Hong Kong. This is the roughdigital model of the project, including a onlooker stand, a main soccer field, and a branched so cerfield, which are built and analyzed using PROCESS ENGINEER and CATIA V5. Through thedigital model, the owner and consultant discussed the general arranging of the sports ground andmodified it until it satisfied the owner's needs. It can be seen that the planning model is very clearand easily understood, especially for the design of the spectator stand.4LCM is not a fixed process but an iterative one. Unlike traditional project management, somechanges continuously occur in the holistic process of LCM so as to meet the requirement of allparties. For instance, when some problems appear in the construction or design phase, the ception of projects needs to be reinvestigated and changed many times. The platform also can provide a virtual environment for convenient and rapid reinvestigation or modification. Otherwise itcan make these changes easily understood by the owner as sometimes owners cannot understandshop drawings or their changes. After the visual planning is finished, the relevant information maybe saved to guide the design.

Design

Following the visual planning, designers, i.e. architect, structure engineer, and BS&EM engineer,may conduct collaborative design via the visual platform and this forms the digital mock-up of theproject, namely the Main Model, using CATIA V5. Figure 7 shows the main model of the TKO project building built by CVPL and which support the following phases. When the design of the architecture, structure and building services is individually conducted in the traditional method,conflicts between these separate designs often occur. The collaborative design process identifiesthese conflicts, for example between a pile cap and an underground pipe in the TKO project (seeFigure 8), and enables them to be modified as soon as possible.The main model of TKO sports ground project5Conflict between pile cap and pipe in the TKO projectt the same time, the constructor (e.g. a consultant or a project engineer) involved in the phaseidentifies the constructability of the design so that the process of construction can be smooth.Rework therefore is minimized or eliminated further to reduce the whole life-cycle cost andtime. The owner and consultant also have early understanding of the design and are able to offer theircomments, so that the design is easily and fastly approved.

Although many design errors and constructability issues are recognized before construction, some problems still occur in the procedure of actual construction. These also need to bear all of theplatform to analyze the design. Thus the main model of the project is an important data entity of the VP-based LCM information platform. It provides a great deal of data for the construction, commissioning and maintenance of the project.

Construction

In the construction phase, the concentration of the LCM is on construction methods, construction techniques, the utilization and allocation of resources in order to monitor construction time, cost and quality. Different projects need different construction methods, that is, the construction method for the project is usually unique. Contractors or

subcontractors can utilize the VP-based informationplatform
to freely simulate and discuss the method of construction to decide the optimal construction method, construction sequence, and resource leveling and test new construction techniques before actual construction is commenced. The platform can also be adopted to simulate the planning of construction, make the entire process smooth in the virtual environment, and provide working guides for workmen. This reduces or eliminates the rework of construction, reduces the construction cost and time, and improves the quality of projects.
The holistic simulation method is conducted using DELMIA V5.

Simulation of roof truss installation in TKO project

By using the simulation, owners or consultants may conveniently interact with contractors or subcontractors and know in detail about the construction process and methods for the construction statements to be efficiently approved. For old LCM or project management approaches, it is very difficult for owners or consultants to know about the construction methods and thereforemuch more time is needed on the approval of construction statements. Additionally, the finalsimulation can capture and save much knowledge for future projects and support future maintenance.

Utilization

The main model of the building projects established using the VP technology also offers a management platform for property management. Currently, many buildings have been managed via employing management information systems, and most of them adopt the plan, elevation or section of a building to manage inhabitants in fire control. However, only professionals can understand all of these drawings. Although some of management details systems introduce 3D models of buildings, the same model needs to be post- developed, which is time-and-cost waste. Thus it is useful and convenient to construct and apply the main model using the VP-based LCM approach to the management of buildings. This not only minimizes management costs but also ensuresadequate safety.

Maintenance

The main model of the building provides visual data for maintainers to maintain or change some parts of building or devices. This is mainly important for some non-typical buildings,
e.g. sports grounds. The drawings related to the building are in such great quantity that they aretough to preserve. Often after 5-10 years, they are destroyed. When maintaining the building, relevant drawings are not available. Although some of electronic drawings,
e.g. CAD drawings, are currently stored in computers, these 2D drawings are generally difficult to be understood by maintainers. The 3D main model can help maintainers do this easily and clearly. Also, the main model includes much manufactures' information, for example name, telephone, address, etc, and the information of devices or material, e.g. name, type, etc. This information integrated with the main model can aid maintainers to select matching material, devices, etc. Maintainers onlyneed to click on an item to get its matching information and therefore it is easy to use the platform.

Discussion

Advantages of implementing a VP-based LCM

LCM appears to have a large number of advantages, e.g. reducing the risk, time, and moneyof operating a project and enhancing the service level to owners/tenants during the whole life cycle. The advantages of the Virtual Prototyping-based information platform in different phases oflife cycle of projects are summarized in Table 1. It is obvious that the VP technology makes an necessary improvement to the LCM of projects, mainly in the design and construction phases, while from experiences, the time and cost of implementing the VP technology is much smaller than thetime and cost savings. Such a level of performance is not possible to be identified in the traditionalLCM of construction projects.

Case study of cost and time saving in the construction phase

As a easy case study of the need of VP-based LCM, the cost and time saving in the construction phase is given for several real-life construction projects in Hong Kong and Macau. All data are combined from relevant contractors, that is, these dataare

empirical. In some cases the situation is not clear due to lack of information.
Money and time savings in the construction phases of real-life buildings in Hong Kong
Project name Cost saving Timesaving
Kwai Chung Public
Housing
Unclear About 17% HKCC
Unclear Unclear
Ho Tung Lau About 12% About 5% Venetian
Macau Hotel About 5% UnclearTKO Sports
Ground About
250HKD
About 1month
From the data provided, although not including all data from the holistic life cycles ofprojects, it is clear that the VP technology can make the LCM much useful .

Conclusions

LCM has been a necessary feature of the construction industry for long years, but has not been successful in its application as yet. It lacks an effective communication and collaboration data platform to support data sharing between different parties. This paper gives a new data sharing platform using VP technology via analyzing the information flow of LCM of construction buildings and customizing the platform byDASSAULT software. The process of executing LCM of projects is presented on the need of the VP-basedinformation platform. The merits of implementing VP-based LCM are further discussed and it is seen that the VP technology can provide needed support to implementing the LCM of construction projects. However, Virtual Prototyping-based LCM of construction projects isstill in its lower stage and much further research is still needed. For example, the delivery approach (e.g. Design-build)of a project has an use on the implementation of VP-based LCMsince it affects the participants during different phases; although this paper shows the meritsof the VP-based LCM platform for the construction side, these data are empirical, and a quantitative method is needed to quantitatively analyse the merits of the platform. These allneed to be further analysed.

References

1. Ameri, F., and Dutta, D. (2004). "Product lifecycle management needs, concepts and components". *Technical Report*, <http://www.plmdc.engin.umich.edu> (May, 2004).
2. An, X. H. (2003). "Lifecycle management for construction project based on IT". *Intelligent Building and Urban Informatization*, (4), 70-72.
3. Bonnal, P., Gourc, D., and Lacoste, G. (2002). "The life cycle of technical projects". *ProjectManagement Journal*, 33(1), 12-9.
Chaaya, M., and Jaafari, A. (1999). "Integrated design management within a life cycleproject management paradigm". *Proceedings of the Second International Conference onConstruction Process Re-engineering*, Australian Center for Construction Innovation, Sydney, Australia,279-289.
4.Chalfant, R. V. (2001). "The benefits of life-cycle management". *Iron AgeNew Steel*,17(1)
5.Choi, S. H., and Chan, A. M. M. (2004). "A virtual prototyping system for rapid productdevelopment". *Computer-Aided Design*, (36), 401-412.
6.Doloi, H., and Jaafari, A. (2000). "Application of simulation tool for strategic decision evaluation for life cycle project management". *Proceedings of the 17th International Symposium onAutomation and Robotics in Construction (ISARC 2000)*, National Taiwan University, Taipei, Taiwan,739-744.
7.Ellicott, M. A. (1994). "Best-value contracting". *Proceedings of Area Engineer's Conference*, TransAtlantic Division, US Army Corps of Engineers.
8.Garetti, M. (2004). "PLM: a new business model to foster product innovation". *Proceedings of the International IMS Forum 2004: Global Challenges in Manufacturing*(2), Villa-Erba-Cernobbio, Italy, 917-924.
9.Gransberg, D. D., and Ellicott, M. A. (1997). "Life cycle project management". *AACE International Transactions*, 288-292.
10.Gross, S., and Fleisch, E. (2004). "Maintenance improvement by unique product informationenabled by ubiquitous computing". *Proceedings of the 11th IFAC Symposium on*

InformationControl Problems in Manufacturing, Salvador, Brazil, 65-70.
11. Hayes, R. H., and Wheelwright, S. C. (1979a). "Link manufacturing process and product lifecycles: Focusing on the process gives a new dimension to strategy". *Harvard Business Review*,57, 133-140.
12. Jaafari, A., and Manivong, K. (1998). "Towards a smart project management information system". *International Journal of Project Management*, 16(4), 249-265.
13. Kovacs, G., Kopacsi, S., Haidegger, G., and Michelini, R. (2006). "Ambient intelligence in product life-cycle management". *Engineering Applications of Artificial Intelligence*, 19(8), 953-965.
14. Lee, S. H., Pena-Mora, F., and Park, M. (2006). "Dynamic planning and control methodology for strategic and operational construction project management". *Automation in Construction*,15(1),84-97.