Preface

BEING LOST OR BECOMING LOST

When Oceanic Flight 815 from Sydney to Los Angeles crashed on a mysterious tropical island in the South Pacific, none of the survivors were aware that they were actually LOST in their own lives. Instead, they were concerned with being physically LOST on an abandoned island. In fact, after 5 years of the TV Show and over 100 episodes, viewers became to realize that these 'Losties' could only become aware of their difficult and mysterious situation after spending several years in and out of the island.

Although a fictional TV show, similarities can be drawn from when the term Building Information Modeling (BIM) was coined through the 1990s with a similar path of destiny for the users of the digital building models in the AEC industry beginning to emerge, leaving the industry (the BIM Losties of 2010) with many questions to be answered, such as:

- Were we not actually Modeling the 'Building Information' in the 2D CAD era, before the term 'Building Information Modeling' was brought to our attention?
- When working on BIM, are we trying to establish a standard shared digital building model, a new collaborative methodology for managing projects, or are we chasing to achieve a paradigm shift for the traditional processes of the industry?
- Will BIM help us to transform the production processes in a form that is leaner, greener, and where industrial functions can be digitally managed or will it only cause us (the users/stakeholders of BIM) becoming 'LOST' between the complexity of real life industry processes and modeling phenomena of the AEC universe?

Questions such as these have motivated us in a hopeful search for understanding Building Information Modeling, from its roots to its functions, from its capabilities to its possibilities. In the late 1990s, Building Information Modeling was prescribed as a remedy for the illness of 'Data Interoperability' in AEC industry. However, it is now apparent that this '*magic remedy*' can cure much more '*illnesses*' than it was originally prescribed for. It can also facilitate so many different functions of the AEC industry and even beyond, such as in Urban Management. In addition, Building Information Modeling is now becoming a key vehicle for transforming the paper based and heavily fragmented processes of the AEC industry. Having discovered the 'magic' that this new remedy can provide the industry is now heavily concerned with implementing it in many different fields. Despite the enormous amount of effort that is being carried out, it is still not very clear whether BIM will lead the industry to find its way and transform work practices to the desired collaborative form or it will just cause the industry to become 'LOST' in the AEC Modeling universe till eternity.

BUILDING INFORMATION MODELING

As readers of this book will be quite familiar with, the AEC industry is highly fragmented and thus integrated ways of working are always an apparent need for the industry. The Integrated Project Delivery (IPD) approach which recently emerged in US reflects the perspective on the future of project life-cycle management and project delivery. IPD encourages early contribution of knowledge and experience and requires proactive involvement of key participants. The IPD Working Definition (2007) states that Building Information Modeling is essential in efficiently achieving the collaboration required for IPD. Input from the broader integrated team coupled with BIM tools to model and simulate the project enable the design to be brought to a higher level of completion before the documentation phase is started. Thus, the project is defined and coordinated to a much higher level prior to the start of construction, enabling more efficient construction and a shorter construction period. From an Integrated Project perspective Building Information Modeling can be defined as:

The information management process throughout the lifecycle of a building (from conception to demolition) which mainly focuses on enabling and facilitating the integrated way of project flow and delivery, by the collaborative use of semantically rich 3D digital building models in all stages of the, project and building lifecycle.

BUILDING INFORMATION MODELS

As mentioned earlier, the Building Information Modeling process is unique as it is based on digital, shared, integrated and interoperable Building Information Models. Thus, Building Information Modeling can be defined as the process and facility that enables information management, while Building Information Model is,

the (set of) semantically rich shared 3D digital building model (s) that form(s) the backbone of the Building Information Modeling process

Based on a review of a variety of academic and industrial resources, Isikdag *et al* (2007) have identified the definitive characteristics of Building Information Models as being;

1. *Object Oriented:* The models are defined in an object-oriented nature.
2. *Data-rich / Comprehensive:* Models are data rich and comprehensive as they cover and maintain all physical/functional characteristics and states of the building elements.
3. *Three dimensional:* Models always represent the geometry of the building in three dimensions.
4. *Spatially-related:* Spatial relationships between building elements are maintained in the BIMs in a hierarchical manner (allowing for several geometric representations such as Constructive Solid Geometry, Sweeping and BRep),
5. *Rich in semantics:* Models maintain a high amount of semantic (functional) information about the building elements. And finally,
6. *Models support view generation:* The model views are subsets or snapshots of the model that can be generated from the base information model. The model views can be automatically derived with respect to the user needs.

Although BIM is the key enabler of the IPD process, BIM goes beyond the management of information in the IPD process in that the process concludes with the closeout stage following construction, while the BIM process continues even beyond the demolition (disposition) stage, i.e. as a process of knowledge management for future projects.

Depending on the environment they are used, Building Information Models can have different functions such as being a *Space Linker* that links macro and micro urban spaces, an *Interoperability Enabler* which facilitates information sharing between various stakeholders and the software applications they use, a *Data Store* which stores the building information throughout the lifecycle of a building, a *Procurement Facilitator* that facilitates several procurement related tasks in the building lifecycle, a *Collaboration Supporter* through enabling the use and management of shared building information in real-time, a *Process Simulator* by facilitating the simulation of construction processes (i.e. @ nD), a *System Integrator* which enables the integration of several information systems across the industry, a *Building Information Service* which can serve real-time on-demand building information over the internet, a *Green Builder* that enables advanced analysis supporting the design and construction of environment friendly/energy efficient buildings, and a *Life Saver* which facilitates emergency response operations.

THE HANDBOOK

The *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies* focuses on providing an up-to-date comprehensive and collective perspective of both the latest leading-edge research along with the current understanding and practice in the area of BIM and Construction Informatics within the global construction industry. The overall objectives of the handbook are to:

- Provide a unique comprehensive and collective perspective of BIM to-date along with the opportunity to initiate the debate towards an agreed definition.
- Bring together the current collective body of knowledge of academic research with that of industry understanding and practice in order to provide a holistic picture of Building Information Modeling within the industry.
- Provide contrasting and comparative perspectives on the latest leading-edge research from academia with the understanding and practice of both the AEC and other related knowledge domains.
- Provide a future reflection of the direction for BIM in identifying the barriers and addressing their resolve.

In order to meet these objectives the editors chose to select as many diverse perspectives as possible. The *Handbook of Research on Building Information Modeling and Construction Informatics: Concepts and Technologies* brings together a broad field of experts from civil and mechanical engineering, architecture, computer science, software engineering, geographical information science, urban planning and management, and surveying. Additionally, the *Handbook* maintains a global approach in that the contributors are scholars and professionals from *Australia, China, Denmark, Germany, Hong Kong, Netherlands, Norway, New Zealand, Singapore, Slovenia, Taiwan, Turkey, U.K.* and the U.S. with diverse research perspectives utilizing both qualitative and quantitative methodologies. A world of authors from academia and industry and an array of research methods presented contributed to the extraordinary

quality of the chapters addressing this very timely topic of Construction Informatics which has begun to pick up pace.

CHAPTER FEATURES

Within the *Handbook* the expertise, knowledge, wisdom, scholarship, and talent of the authors are shared with the reader in nine sections. The organization of the chapter generally follows this format: abstract, introduction, background, body, conclusion, references, key terms and definitions. The *Handbook* is organized as follows.

Section 1: Introduction

This first section concentrates on exploring the conceptual aspects of both BIM and Building Information Models including examining the purpose of Building Information Models. The concepts of what is actually being modeled and the way in which these can be modeled are discussed in this section. This is complimented with the perspective of Architectural Design being presented. The Handbook begins with *Chapter 1* of van Nederveen, Beheshti and Gielingh discussing the Modeling concepts of Building Information Modeling by addressing questions such as What is Building Information Modeling? , What is a Building Information Model? along with the rationale and objectives of a Building Information Model. In the following chapter, *Chapter 2*, Çetiner provides an introductory review of Building Information Modeling from an Architectural Design perspective. In the chapter, she also discusses the capabilities of several different Building Information Modeling tools.

Section 2: Adoption

Adopting the BIM approach is not just about the technology but is also highly dependent on other 'non-technical' factors relating to people, process, organisational structure, work environment, etc. The focus of this section is towards exploring the issues associated with the readiness and maturity of organisations in preparing themselves for the successful adoption of BIM. The section begins with *Chapter 3,* whereby Bew and Underwood, from the premise that BIM does work and adopting such an approach in the competitive UK market is worthwhile, focus on exploring the aspects of an awareness of what is involved, understanding the evolution, and taking sensible steps to achieve the reward towards the delivery of BIM to the UK construction market sector. In *Chapter 4,* Succar in the first stage explores the multi-dimensional nature of the BIM domain and then introduces a knowledge tool BIM Maturity Matrix (BIm^3) to assist individuals, organisations and project teams to assess their BIM maturity and improve their performance.

Section 3: Standards

A key element to BIM which is firmly fixed in its origin is that of standards. This section is concerned with standards from two particular aspects. The first is that of product modeling within the AEC sector in terms of an extensive historical review, the characteristics of several conceptual approaches together with the implementation of their constructs, and finally future trends through a number of on-going research

projects. The second aspect is a recent national standard which has been set up in the US is examined in relation to the current and future strengths, weaknesses, opportunities, and impact. In *Chapter 5*, Dado, Beheshti and van de Ruitenbeek provide a synopsis of product Modeling history in the Building and Construction (BC) industry based on the authors' experiences gained from various conducted research projects and also taking into account results of other research projects. After this historical overview, an analysis of the characteristics of interesting conceptual product Modeling approaches are presented and discussed. In the following chapter, *Chapter 6*, Suermann and Issa provide an overview on the strengths, weaknesses, opportunities, and impact of the National BIM Standard (NBIMS) into 2009 and beyond. The chapter focuses on some of the strengths of the NBIMS such as promulgating a standardized approach for documenting information exchanges between stakeholders, and applying the NBIMS Interactive Capability Maturity Model (I-CMM) to evaluate a project or portfolio for BIM maturity.

Section 4: Applications

This section focuses on various aspects of applications in support of the BIM process including proposed technology developments, new approaches to applications development, and conceptual implementation frameworks. The section starts with *Chapter 7* authored by Yu-Cheng Lin, which presents a pilot study on the use of Building Information Models for management of the construction/mechanical/electrical interfaces in a project. The chapter also provides an overview of a CAD-based Interface Management (CBIM) system developed during the study. The CBIM system is later applied in Taiwan to demonstrate the effectiveness of BIM in Interface Management. *Chapter 8* is authored by Olatunji and Sher and reviews the impacts of BIM on cost estimating procedures. In order to develop a conceptual framework for underpinning BIM-propelled changes in estimating practice, Computer Aided Estimating applications are categorized and compared. In addition, some features for producing automated quantities from BIMs are compared with provisions of standard methods of measurements used by estimators. In *Chapter 9*, Rebolj, Čuš Babič and Podbreznik describe methods of automating the monitoring process of a construction project before concentrating on a solution which takes into account all three aspects of project management: coordination, control and communication. In this solution the activity progress is monitored directly by using a combination of data collection methods, which are based on the Building Information Model, especially on the 4D model of the building. *Chapter 10* is authored by Spearpoint who first looks at what fire engineers would like to achieve and how BIM fits in with those goals. The chapter later discusses the types of fire simulation models that fire engineers use and provides a brief description of two particular fire growth models which use different means to represent a fire scenario. The chapter finally considers how the IFC building product model can be used to transfer building geometry and property data to fire simulation models. In the following chapter, *Chapter 11*, Olatunji and Sher review some of the capabilities of BIM which may revolutionize conventional practices in FM. The authors outline that the capabilities provided by BIM such as project visualization, simulation, auto-alert and value intelligence may stimulate major improvements in facilities management processes. *Chapter 12* is authored by Hartmann who presents a different method to design software - context sensitive software development – and he indicates that it is possible to enable application developers to adjust BIM based applications to the varying and frequently changing work processes of AEC professionals. In the final chapter of this section, *Chapter 13*, authored by London, Singh, Gu, Taylor and Brankovic, an action research study towards the development of a decision framework to support a fully integrated multi disciplinary Building Information Model using a Model Server is discussed. The Framework consists of

four inter-related key elements including a strategic purpose and scoping matrix, work process mapping, technical requirements for BIM tools and Model Servers, and framework implementation guide.

Section 5: Green Building

Green issues and sustainability are firmly high on the global agenda. This is a major concern to the AEC industry which has a significant role to play in addressing these issues. This section examines the opportunities for BIM to facilitate the delivery of green and sustainable projects and ultimately leading to a green and sustainable industry. In *Chapter 14*, Fernández-Solís and Mutis explain their propositions on Green as a concept that gives direction on what to do right (effectiveness), on Lean that captures how to do it right (efficiently), and on BIM as an enabling platform that will facilitate the implementation of this effort. BIM, Lean, and Green (BLG) will allow a rapid prototyping of design and construction, the integration of drawings, specifications, and manufacturing in a Green best practice ambient that employs benchmarked Lean principles. The following chapter, *Chapter 15*, is authored by Goh Bee Hua and focuses on describing (a proposed) rule-based system that contains decision-support rules pertaining to the assessment of (whole-life) cost to support 'Green Building' concept decisions.

Section 6: Spatial Applications

In recent years, the benefits of integrating the traditionally isolated areas of building and geo-spatial information have begun to be explored. This section focuses on current research efforts towards integrating BIM at the urban scale along with an industry perspective on the value that it can realise.In the first chapter of this section, *Chapter 16*, Song, Bogdahn, Hamilton and Wang review recent research into the integration of geo-spatial and building information from the perspective of an EU project focused on developing a Virtual Environmental Planning System. In the following chapter, *Chapter 17*, Wang and Hamilton provide an insight into their work on the design and development of a BIM web service - Building Feature Service (BFS) - which is defined to retrieve building information similar to OGC web services (used for retrieving geospatial information). In *Chapter 18*, Borrmann and Rank introduce a spatial query technology for BIMs that has been developed by them. The developed technology allows users and third-party application programmers to not only analyze the digital building under specific criteria but also to extract partial geometric models on demand from a full building model. *Chapter 19* authored by Paul, presents a generalizing concept which handles both "local" and "global" connectivity information (of geometric representation of the objects) in a common way and provides methods to mutually relate them in Building Information Models. The Chapter 20, authored by Isikdag, Underwood, Kuruoglu and Abdul-Rahman, presents a web service pattern enhancement that will help in facilitating information transfer from Building Information Models into the geospatial environment. In *Chapter 21,* Peters explores the value of integrating BIM and Geospatial Information Systems into a single system from an industrial perspective, and how this integration can be achieved.

Section 7: State of the Art

This section explores the current state of BIM in the AEC industry. The focus is on the positioning of BIM adoption across disciplines in relation to their current status and future expectations which are based on such factors as the tools, people and processes. The extent to which BIM has been implemented and

the factors currently both facilitating and impeding adoption within the Australian AEC industry are also explored. In the first chapter of this section, *Chapter 22*, Gu, Singh, Taylor, London and Brankovic present a comprehensive analysis of the current state of Building Information Modeling (BIM) in the Architecture, Engineering, Construction and Facility Management (AEC/FM) industry. *Chapter 23* is authored by Gerrard, Zuo, Zillante and Skitmore and reviews the development of BIM, the extent to which BIM has been implemented in Australia, and the factors which have affected the up-take of BIM.

Section 8: Training and Education

This penultimate section focuses on aspects of education and training which are becoming increasingly important in facilitating industry-wide adoption through increasing industry awareness along with the development of professionals with the necessary capability and skills. In *Chapter 24,* Harty and Laing review the barriers to BIM adoption from a training/education perspective, and indicate that an emerging professional, the Architectural Technologist, can bridge that divide and adopt the adjunct role of manager in the IPD. In the following chapter, *Chapter 25*, Tanyer presents the design and evaluation of an undergraduate course which aims to convey both the theoretical and practical principles of integrated design. In this new course, students aim to deliver a design project collaboratively by exchanging data between applications. The evaluation of the course has revealed various barriers related to implementing integrated design principles at educational programs.

Section 9: Case Studies

With BIM now being widely adopted across the globe and on a variety of projects, this final section introduces a number of real-life cases. Through these cases various issues to adopting a BIM approach together with the realised benefits and lessons learned are discussed. *Chapter 26* is authored by Moum and investigates the main factors affecting the practitioners' use of BIM, and how BIM impacts their work and interactions. The author presents a holistic research approach as well as the findings from its application in four real-life case studies. In *Chapter 27* Lostuvali, Love and Hazleton discuss the synthesis of lean production principles and techniques applied in AEC forming the basis for a Lean Project Delivery System™ (LPDS). The authors then present a case study which provides an overview of the synergy between the principles and tools of LPDS with BIM technologies. The *Handbook* concludes with *Chapter 28* authored by Riese which provides an overview to numerous different real-life cases from Hong Kong on the use of BIM / Building Lifecycle Information Management.

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