Journal of Contemporary Research in the Built Environment ISSN: 2636-4468
Volume 2, Numbers 1&2, 2018

CONCEPTUALISATION OF BUILDING INFORMATION MODELING (BIM) TECHNIQUE IN REAL ESTATE DEVELOPMENT

Paul Chuks Anih[1] and Ikenna Reginald Ajiero[2]
[1]Department of Estate Management, University of Uyo, Uyo, Nigeria
[2]Department of Building, University of Uyo, Uyo, Nigeria

ABSTRACT

Purpose: In consideration of the modernity in the trend of real estate development projects, this paper purposed to introduce Building Information Modeling (BIM) approach to the professionalism of estate surveying and valuation as a tool to bridge the gap in attaining international best practices in real estate development.
Design/methodology/approach: The study adopted a qualitative approach to the presentation. It is a conceptual paper involving literature reviews and explanations of concepts, graphics, and models. The study did not involve field observations of collation of numeric data. The functions carried out by Estate Surveyors and Valuers were compared with the components of BIM such as 3-D, 4-D, etc., to show the relevance of the concept in real estate development.
Findings: Building Information Modeling (BIM) was noted to be an emerging trend in the construction industry amidst the third world nations and Nigeria in particular. This is not the same with advanced countries such as the United Kingdom (UK) and the United States of America (USA). The advanced countries are implementing the technetronic of BIM to match the advancement in the construction industries. The development of 3-D, 4-D, 5-D, 6-D and 7-D with their specialties are great attributes of this modeling. This is profitable for shared knowledge resource for information about a facility forming a reliable basis for decisions during property life cycle from inception to conclusion.
Research Limitations/Implications: The limitation of the study was on the poor awareness of the parts of Estate Surveyors and Valuers who were conversed with, to find out if they know about BIM. The situation was not peculiar to the estate surveyors alone but even to some professionals in practice in the construction industries. The limited awareness was majorly on theory not on practicum.
Practical Implications: It is pertinent to develop inclusive theoretical enlightenment supported with realistic practical exercises. This can be achieved with a good knowledge base in computer and software applications like AutoCAD, CADD and other related computer software. There should be a knowledge bridge linking theory and practice by organizing seminars, workshops, and conferences.
Originality/value: The work is original. It is not copied, presented elsewhere or published. It is very valuable to Estate Surveyors and participants of the Architecture, Engineering and Construction industry. The need to conceptualize BIM in real estate development accounts for inestimable benefits in advancing the profession to match with global best practices.

[1]paulanih@uniuyo.edu.ng

Keywords: Building information modeling; Estate Surveyors and Valuers; global best practices; real estate development.

1. INTRODUCTION

This paper examines the need to conceptualize building information modeling (BIM) technique in carrying out real estate development in Nigeria. Real estate development is encompassing and involves several professionals in real estate related fields such as estate surveyors, town planners, architects, builders, etc. Real estate development is part of an activity carried out by estate surveyors, in synergy with builders and other professionals. Estate surveyors undertake critical roles in real estate development from the conceptual stage of the development to the completion and letting stage of the property. The traditional approach to real estate development at the preconstruction stage which involves architectural depictions is usually with 2D plans. This system is presently giving way to a more digitalized approach known as Building Information Modeling (BIM) with its unique 3D, 4D, 5D, 6D, and 7D modeling. BIM is not very popular in developing nations including Nigeria but it is extensively in use in developed nations. This study explores the benefits of this technique to estate surveyors by reviewing its applications as adopted in some developments. The study adopts a qualitative approach to the presentation. It is a conceptual paper involving literature reviews and explanations of concepts, graphics, and models. The study did not involve field observations of collation of numeric data. The functions carried out by estate surveyors and valuers were compared with the components of BIM such as 3-D, 4-D, etc., to show the relevance of the concept in real estate development.

2. CONCEPT AND EMERGENCE OF BUILDING INFORMATION MODELLING

Debasis and Raj (2015) explain Building Information Modeling (BIM) as a process involving the generation and management of digital representations of physical and functional characteristics of a building or a facility. It was further explained as a holistic documentation process for operational visualization, design coordination, estimation, and project scheduling. Dana (2008) and US National Building Information Model Standard Project Committee revealed that BIM serves as a shared knowledge resource for information about a building forming a reliable basis for decisions during its life cycle from inception onward. Dana further maintained that the basic premise of Building Information Modeling is a collaboration by different stakeholders at different phases of the life-cycle of a facility to insert, extract, update or modify information in the Model to support and reflect the roles of that stakeholder.

Debasis and Raj also adduced that BIM is an integrated 3D model containing data relevant to all participants of the investment process, including investors, designers, contractors, managers, and owners of the facilities. It provides almost unlimited possibilities in terms of presentation and analysis of the project, for instance, identifying collisions or change management. This could be possible through the use of BIM software which defines objects parametrically and it is a tool for virtual reality. Debasis and Raj pointed that basic advantage of implementing BIM is the visual coordination of the building

structure and systems such as Mechanical, Electrical and Plumbing (MEP) and it also identifies the possible conflicts between the building systems. The explanation here emphasized on digitalization as distinguishing attribute of BIM. Prior to the emergence of BIM, the traditional approach to real estate development was not digitally implemented.

Eastman, *et al*. (1974, 2008 and 2011) disclosed that the building information model emerged from the term 'building model.' Ruffle (1986) confirmed that the idea of building model has been a subject of discourse: it was first discussed in a paper presented by Ruffle (1986), and later discussed again in another paper by Aish (1986) then at Gollins Melvin Ward (GMW) Computers Ltd, the developer of RUCAPS software (Laiserin, 2008). Van-Nederveen and Tolman (1992) consented that the term 'Building Information Model' and 'Building Information Modelling' (including the acronym "BIM") did not become popular in use until some decade later. Autodesk (2002) drew the attention of some software vendors who began to assert their participation in the field. Laiserin (2002 and 2003) observed that contributions from Autodesk, Bentley Systems and Graphisoft, including other industry observers, helped to popularise and standardize the term BIM as a common name for the digital representation of building process.

3. IMPORTANCE OF BUILDING INFORMATION MODELING (BIM) TO REAL ESTATE DEVELOPMENT

The desire to own real estate has to be purpose driven. The purpose could be based on either investment or owner-occupied. When this decision is settled, then the planning, design, and construction takes off. The initial activity of real estate development is at the conceptual stage and demands the attention of an estate surveyor and valuer. An estate surveyor/valuer is an expert in land matters and plays a key role in land acquisition for development. BIM is a landless digital concept of a virtual development of a building and requires the ingenuity of an estate surveyor to realize. Eastman, et. al (2011) agree that BIM is designated at pre-construction stage by designers for conceptual design, sketching, space planning, orientation on site, and ensuring program compliance with regards to site-related factors. Lincoln and Syed (2010) buttressed that BIM is also identified to help in predicting building performance and also helps in reducing construction wastes. It can also reduce the adverse impact of construction and helps to integrate analysis, simulation, and visualization into workflow primarily to make informed decisions throughout the project life cycle. Debasis et al. (2015) stated that BIM is an intelligent model-based process that provides insight for creating and managing building and infrastructure projects with faster speed, economy, and quality.

Jim (2011) argued that prior to the advent of BIM; traditional building design was largely reliant upon two-dimensional technical drawings (plans, elevations, sections, etc.). Thus, Building Information Modeling (BIM) is a process involving the generation and management of digital representations of physical and functional characteristics of places. Cinti and Garagnani (2012) observed that building information models (BIMs) are files (often but not always in proprietary formats and containing proprietary data) which can be extracted, exchanged or networked to support decision-making regarding a building or other built asset. Current BIM software is used by individuals, businesses and government agencies that plan, design, construct, operate and maintain diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, railways, bridges, ports, and tunnels. As a rule, the use of 3D models: improves the ability for the project presentation, significantly improves the communication between the participants of the

investment process and reduces the amount of work. Kiziltas, et. al. (2009) asserted that building information modeling extends beyond 3D modeling, augmenting the three primary spatial dimensions (width, height, and depth) with time as the fourth dimension (4D). 3D modeling (or three-dimensional modeling) is the process of developing a mathematical representation of any three-dimensional surface of an object via specialized software.

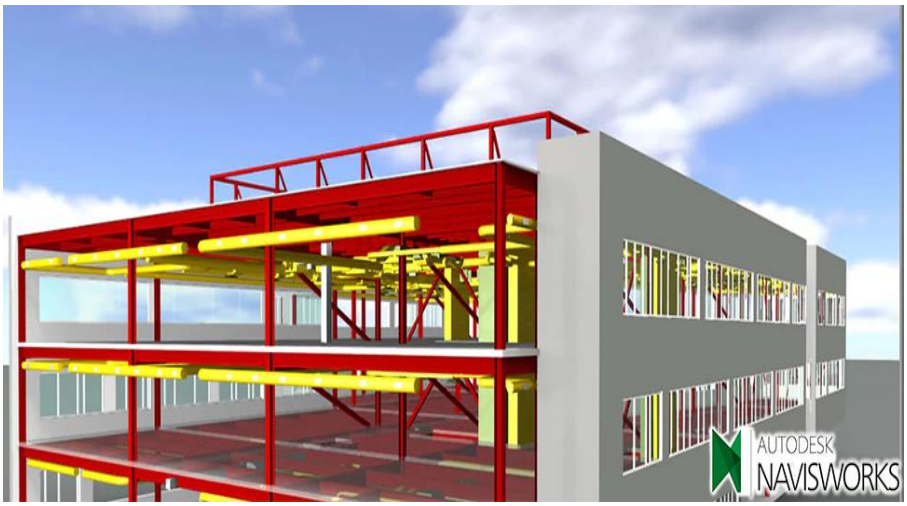

Fig. 1: Actual Structural Model that represents the 3D view of the structural framework of the building.
Source: AUTODESK - NAVISWORK

4. THE GROWTH OF THE BUILDING INFORMATION MODELING FROM 3D – 7D AND ITS APPLICATION IN REAL ESTATE DEVELOPMENT

Figure 1 shows a resulting model of a three-dimensional (3D) representation of the constructed facility. The 3D model thus generated is a virtual model which is digitally constructed to simulate planning, design, construction, and operation. It works on parametric rules and supposed to contain data attributes pertaining to different fields. 4D BIM refers to the intelligent linking of individual 3D CAD components or assemblies with time- or schedule-related information. The use of the term 4D is intended to refer to the fourth dimension: 4D = 3D + schedule. The construction of the 4D models enables the various participants of the construction process (designers, contractors, investors) to visualize the entire duration of a series of events and display the progress of construction activities through the lifetime of the project. This BIM-centric approach towards project management technique has a very high potential to improve the project management and delivery of construction project, of any size or complexity. The use of BIM 4D allows you for better control over the implementation of the investment process. This involves the ability to detect conflicts before proceeding to execute the task, effectively managing change and risk, or to support communication between the participants of the whole process. Schedule, as a rule, is fully compatible with the 3D model.

McKinsey (2015) identified 5D-BIM as one of five trends that will change the future of the global construction industry. McKinsey says “Combining 5D-BIM and augmented-reality devices will transform construction, maintenance, and operations. To get the full

benefit of BIM technology, project owners and contractors need to incorporate its use right from the design stage, and all stakeholders need to adopt standardized design and data-reporting formats compatible with BIM. In addition, owners and contractors need to dedicate resources for BIM implementation and invest in capability building. 5D-BIM is an evolving segment in the construction industry, comprehending the customary three-dimensions of a BIM with the schedule as the fourth dimension and cost estimates as the fifth dimension. The 5D-BIM approach offers an exceptional opening to unite practices in design, cost and construction approaches. On the other hand, it should be noted that 5D BIM approaches call for a significant change in the way construction companies work.

ASHRAE (2012) reveals that recently there are also references to a sixth dimension (6D) representing building environmental and sustainability aspects, and a seventh dimension (7D) for through-life facility management, although there are conflicting definitions (6D BIM). BIM covers more than just geometry. It also covers spatial relationships, light analysis, geographic information, and quantities and properties of building components (for example, manufacturers' details). 6D BIM facilitates the implementation of energy analysis for buildings. Use of 6D allows for more accurate and comprehensive energy analysis of the building already at an early stage of the design process. It also allows you to measure and verify the data on the stage of use of the building in such areas as real energy demand for the building. Based on the simulation model created on the basis of collected data we raise the relevance and quality of the projects, which translates into reduced power consumption.

BIM 7D is used by managers in process of the object management on the stage of its operation. 7D allows participants of the process to extract and store data assets, such as the state of the object/component, technical specifications, required maintenance schedule and technical reviews, manuals or applicable warranty period. Such an approach to the facility management process not only improves the whole process but also improves the quality of services in this area.

5. THE USE OF BUILDING INFORMATION MODELING (BIM) AS A REAL ESTATE PRE-INVESTMENT TOOL

Odudu (1991) argues that Estate Surveyors and Valuers should be engaged at every stage of the development process of a real estate development; from the conceptual stage to the delivery stage. Odudu's argument is that estate surveyors and valuers cannot be avoided in the property development processes. The skill of estate surveyor and valuer in the collective analysis of every stage of the property development process cannot be overemphasized. The basic premise of Building Information Modeling is a collaboration by different stakeholders at different phases of the life-cycle of a facility to insert, extract, update or modify information in the Model to support and reflect the roles of that stakeholder (Dana, 2008). A careful examination of the nitty-gritty of building information modeling reveals that BIM can be used as a tool for feasibility and viability study of real estate development.

Fundamentally, any real estate development that would be sustainable has to pass through feasibility assessment and viability test. Ogbuefi (2002) observed that in many developing countries, feasibility and viability studies were usually not accorded its critical position in overall development equation. He construed that this had led to disastrous effects on the overall performance and the final outcome of projects. Every development takes place on land and requires an expert on land matters to analyze the economic

propensity of the land so that the development may not fail. Ring and Dasso (1985) argued that judging a site suitable for development is the most basic decision of an investor-developer. They further argued that most other decisions in the development process flow from the site selection decision. They maintained that acquisition of the site or even committing resources to study a site and its potential for development is the first decision. BIM can be used as a maintenance evaluation tool in the area of property management. It can be used to assess defects in building to decide how it can be repaired. BIM is a veritable tool in property management. Property management is the operation, control, and oversight of real estate. This is much akin to the role of management in any business. It is also the management of physical capital assets that are acquired and used to build, repair, and maintain end item deliverables. It involves the processes, systems, and manpower required to manage the life cycle of all acquired property including acquisition, control, accountability, responsibility, maintenance, utilization, and disposition.

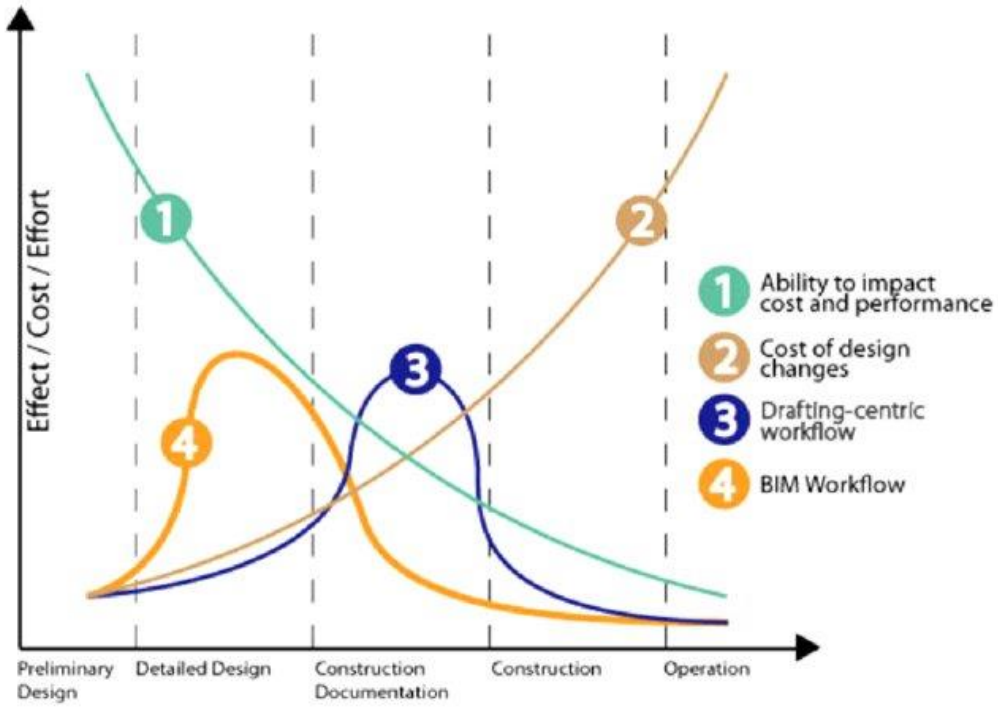

Figure 2: Comparing different distributions for design services. Copyrights: Marcatects

Figure 2 above compares different distributions for design services. This is a model developed by Marcatects. The graph is adopted in this study to illustrate the design service of a building project. The vertical axis represents effect/cost/effort of design services and the horizontal axis represents four levels of activities which are preliminary design, detail design, construction documentation, construction, and operation. The graph (curve) labeled one (1) shows the ability to impact cost and performance. The Curve two (2) shows the cost of design changes, Graph (curve) three (3) shows drafting-centric workflow and the fourth (4) curve or graph shows the BIM workflow. From the graph, the areas where estate surveying and valuation profession are most needed are at the preliminary design and operation. At the preliminary design; feasibility and viability studies, estate agency, public lands administration and land use planning & management are the responsibility areas where the services of estate surveyors may be required. The operation in figure 2 above represents the last stage in the design service of the project. In this case, the operation stage

could be referred to as the handing over or use stage of the completed project for services. The operation stage is the takeover stage when the building is given to estate surveyors and valuers to manage for the service life of the facility. It is at this stage that property management function comes into play for the sustainability of the property. Valuation of the property may be useful to determine the value of the property in case of related financial transactions such as investment decisions, borrowing, sales, etc.

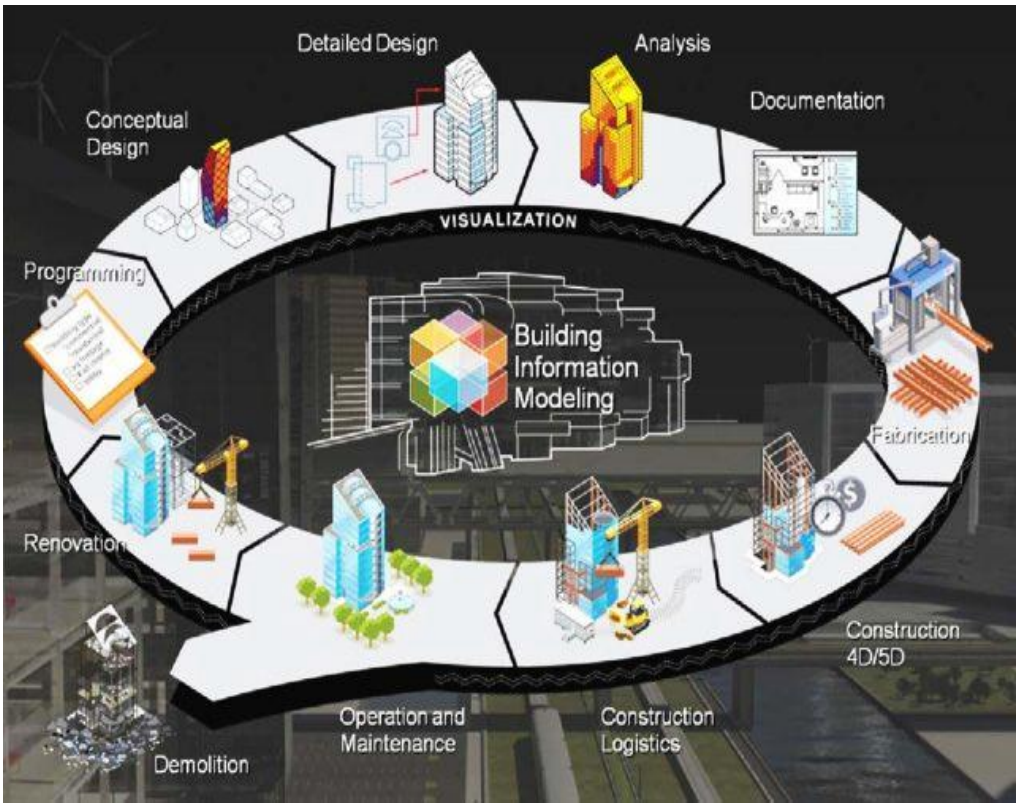

Figure 3: Concept of BIM.

Figure 3 above displays eleven (11) activity areas of building information modeling. The activities in the concept of BIM model above show different roles by various stakeholders who are experts in different disciplines. Estate surveyors' role is obvious in terms of operation and maintenance. The operation is the stage that precedes demolition and it is also regarded as the use stage after construction is completed and the building is ready for occupation. Maintenance stage begins at the inception of taking over for use. Maintenance is a process involved in taking care of the building in a way that depletion in value or quality of the building is avoided. According to Defense Logistics Agency (2016), the technical meaning of maintenance involves functional checks, servicing, repairing or replacing of necessary devices, equipment, machinery, building infrastructure, and supporting utilities in industrial, business, governmental, and residential installations.

Yuseni (2013) stressed that building maintenance management (BMM) is essential to prolong the building life cycle and reduce the owner's loss. When buildings are neglected, defects can occur which may result in extensive and unavoidable damage to the building fabric or structure (European Federation of National Maintenance Societies, 2016). Over time, this has come to often include both scheduled and preventive maintenance as cost-effective practices to keep equipment ready for operation at the utilization stage of a system lifecycle (Wu & Zuo, 2010). From AAP-6 (Glossary of terms and definitions), maintenance

is strictly connected to the utilization stage of the product or technical system, in which the concept of maintainability must be included. In this scenario, maintainability is considered as the ability of an item, under stated conditions of use, to be retained in or restored to a state in which it can perform its required functions, using prescribed procedures and resources (Commercial Electrical Contractor and Domestic Electrician Leeds, 2017). The role of estate surveyor in maintenance is not necessarily carrying out masonry, carpentry or plumbing works but to identify the defect areas that require maintenance and coordinate the various experts to do the job to satisfaction point.

6. INTERNATIONAL PERSPECTIVES OF BIM DEVELOPMENT

Several nations of the world are enrolling in the technique of Building Information Modeling as modernity in advancing the construction industry through virtual design. Countries including India have an expanding construction market and yet BIM usage was reported by only 22% of respondents to a 2014 survey (Sawhney, Anil et al. 2014). BIM Association in Iran (IBIMA) was founded in 2012 and while it was not active, IBIMA aimed to share knowledge resources to support construction engineering management decision-making (Hosseini, 2016). In Malaysia, BIM implementation was led by the Construction Industry Development Board (CIDB Malaysia) under the Construction Industry Master Plan 2016-2020 and emphasized on technology adoption across the project life-cycle to induce higher productivity. Lee, et al. (2012) accounts that small BIM-related seminars and independent BIM effort existed in South Korea even in the 1990s. It was not until the late 2000s that the Korean industry paid attention to BIM. Since 2010, the Korean government has been gradually increasing the scope of BIM-mandated projects.

BIM Summit (2015) calls for greater co-operation as reported in ConstructionWeekOnline.com which accounted that Dubai Municipality issued a circular (196) in 2014 mandating BIM use for buildings of a certain size, height or type. The one-page circular initiated strong interest in BIM and the market responded in preparation for more guidelines and direction. In 2015 the Municipality issued another circular (207) titled 'Regarding the expansion of applying the (BIM) on buildings and facilities in the emirate of Dubai' which made BIM mandatory on more projects by reducing the minimum size and height requirement for projects requiring BIM. This second circular drove BIM adoption further with several projects and organizations adopting UK BIM standards as best practice. In 2016, the United Arab Emirates (UAE's) Quality and Conformity Commission set up a BIM steering group to investigate statewide adoption of BIM.

In France, a Building transition digital plan - French acronym PTNB – was created (mandated from 2015 to 2017 and under several ministries). There was also the French arm of building SMART, called Mediaconstruct (existing since 1989). White (2015) conveyed that in December 2015, the German minister for transport Alexander Dobrindt announced a timetable for the introduction of mandatory BIM for German road and rail projects from the end of 2020. Speaking in April 2016, he said digital design and construction must become standard for construction projects in Germany. In April 2016, Italy included into its own legislation several European directives including 2014/24/EU on Public Procurement. The decree states among the main goals of public procurement the "rationalization of designing activities and of all connected verification processes, through the progressive adoption of digital methods and electronic instruments such as Building and Infrastructure Information Modelling (Department of Public Expenditure and Reform, 2017).

UK Government organized BIM Task Group for BIM programme and requirements, including a free-to-use set of UK standards and tools that define level 2 BIM. The BIM Task Group continues to develop BIM adoption within the government departments. Outside of government, industry adoption of BIM from 2016 has been led by the UK BIM Alliance, formed to champion and enable the implementation of BIM Level 2 by 2020 and to connect and represent organizations, groups, and individuals working towards a digital transformation of the UK's built environment industry. The April 2016 survey of 1,000 UK construction professionals revealed that BIM adoption had increased from 13% in 2010 to 54% in 2015 (NBS National BIM Report, 2016). Several organizations support BIM adoption and implementation in Canada: The Canada BIM Council (CANBIM, founded in 2008), the Institute for BIM in Canada and building SMART Canada (the Canadian chapter of building SMART International). The Associated General Contractors of America and US contracting firms developed various working definitions of BIM that describe it generally as an object-oriented building development tool that utilizes 3-D modeling concepts, information technology, and software interoperability to design, construct and operate a building project, as well as communicate its details. Unlike some countries such as the UK, the US has not adopted a set of national BIM guidelines, allowing different systems to remain in competition (Shapiro, 2014).

The South African BIM Institute, established in May 2015, aims to enable technical experts to discuss digital construction solutions that can be adopted by professionals working within the construction sector. Its initial task was to promote the SA BIM Protocol. There are no mandated or national best practice BIM standards or protocols in South Africa. Organizations implement company-specific BIM standards and protocols at best (there are isolated examples of cross-industry alliances).

7. NIGERIA PERSPECTIVES OF BUILDING INFORMATION MODELLING (BIM)

Nigeria is one of the nations of the world where the concept of BIM is pictured despite the resistance in implementing the idea. Utiome et al (2014) argued that BIM could play a vital role in the Nigerian Architectural Engineering Construction (AEC) sector, adding that its potential clarity and transparency can help to promote standardization across the development industry. They buttressed that, in conceptualizing a BIM-based knowledge transfer framework from industrialized economies to urban construction projects in developing nations, generic BIM objects can benefit from rich building information within specification parameters in product libraries, and used for efficient, streamlined design and construction. In an agreement, Kori (2013) observed that medium and large firms were leading the adoption of BIM in the industry. Smaller firms were less advanced with respect to process and policy adherence. There is little or less adoption of BIM in the built environment due to the resistive nature of the construction industry to changes or new ways of doing things. Till now, the Nigerian construction industry is still working with the 2D conventional CAD system in services and structural designs, although the production could be in the 3D system. There is virtually 0% utilization of 4D and 5D systems.

8. THE IMPLICATIONS OF THE RESEARCH

The BIM concept if fully adopted in the professional practice of any discipline with its technological resourcefulness; it will definitely add value to the growth of the sector. This study identifies poor awareness of the technological trend of BIM in Nigeria as revealed in the literature reviewed (Kori, 2013 and Utiome, 2014). This is implicated on poor development of AEC sector of the real estate industry which affects the economy. Real estate industry is a major resource base of nation's economy. It is therefore pertinent to develop inclusive theoretical enlightenment supported with realistic practical obligations. This can be achieved with a good knowledge base in computer and software applications like AutoCAD, CADD and other related computer software. There should be a knowledge bridge linking theory and practice by organizing seminars, workshops, and conferences.

9. CONCLUSION

Building information modelling (BIM) is a new approach to building an industry that can be useful in real estate development. The study concludes that conceptualization of the use of BIM in the real estate development process will be an advancement in the professional practice of estate surveyors and valuers. The application of BIM in real estate practice especially in projects development will draw specialists in allied professions together to solve knotty issues relating to real estate development. BIM can serve as a pre-analytical tool for real estate development and post-analytical tool at use stage of the real property management.

REFERENCES

AAP-6 - Glossary of terms and definitions". NATO Standardization Agency. North Atlantic Treaty Organization: 158.

Aish, R. (1986). "Building Modelling: The Key to Integrated Construction CAD" CIB 5th International Symposium on the Use of Computers for Environmental Engineering related to Building, 7–9 July. (5): p54-67. https://www.researchgate.net/...Aish/... Building_modelling_the_key_to_integrated_co.. *Retrieved: 22 October, 2018*

ASHRAE (2012). *Introduction to BIM, 4D and 5D". cadsoft-consult.com.* Retrieved 19 October 2018.

Autodesk (2002). Building Information Modeling. San Rafael, CA, Autodesk, Inc" (PDF). *laiserin.com.*

BIM Summit (2015). *Calls for greater co-operation. ConstructionWeekOnline.com*. Retrieved 24th October 2018.

Cinti L. S. and Garagnani, R. M. (2012). "BIM tools and design intent. Limitations and opportunities", in K. Kensek, J. Peng, *Practical BIM 2012 - Management, Implementation, Coordination and Evaluation*, Los Angeles

Commercial Electrical Contractor and Domestic Electrician Leeds". *247 Electrical Services Leeds.* Retrieved 2017-01-26.

Dana K. (2008). Building Information Model. National Institute of Building Sciences. Washington.

Debasis S. and Raj M. (2015). Applications of Building Information Modeling (BIM) to Real Estate Projects of Ahmedabad. *International Advanced Research Journal in Science, Engineering and Technology*. Vol. 2, Issue 9

Defense Logistics Agency". DLA.mil. Retrieved 5 August 2016.

Department of Public Expenditure and Reform (2017). *Government Strategy to Increase use of Digital Technology in Key Public Works Projects Launched. National Development Plan, 2018 - 2027*. Retrieved 24 October 2018.

Eastman, C., Fisher, D., Lafue, G., Lividini, J., Stoker, D., Yessios, C. (1974). *An Outline of the Building Description System. Institute of Physical Planning, Carnegie-Mellon University*.

Eastman, C., Tiecholz, P., Sacks, R., and Liston, K. (2011). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors (2nd ed.). Hoboken, New Jersey: John Wiley. pp. 36–37.*

Eastman, C., Tiecholz, P., Sacks, R., Liston, K. (2008). *BIM Handbook: a Guide to Building Information Modeling for owners, managers, designers, engineers, and contractors (1st ed.). Hoboken, New Jersey: John Wiley. pp. xi–xii.*

Eastman, C., Tiecholz, P., Sacks, R., Liston, K. (2011). *BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors (2nd ed.). Hoboken, New Jersey: John Wiley. pp. 36–37.*

European Federation of National Maintenance Societies". *EFNMS.org*. Retrieved 5 August 2016.

Federal Standard 1037C & MIL-STD-188. Department of Defense. *Dictionary of Military and Associated Terms*

Frej, A. B. and Peiser, R. B. (2003). *Professional Real Estate Development, Second Edition: The ULI Guide to the Business*. Urban Land Institute.

Hosseini, R.,Azari, E., Tivendale, L., Chileshe, N. (2016). *"Building Information Modeling (BIM) in Iran: An Exploratory Study (April 2016)". Researchgate*. Retrieved 24 October 2018.

Jim, J. (2011). Simulation Based Modeling: Structure. *National Council of Structural Engineers Associations (NCSEA).* Houston, Texas. http://structuremag.org/article.aspx?articleID=1234. Retrieved 18th October, 2018.

Kiziltas, S., Leite, F., Akinci, B. and Lipman, R. R. (2009). *"Interoperable Methodologies and Techniques in CAD". In Karimi, Hassan A.; Akinci, Burcu. CAD and GIS Integration. CRC. pp. 73–109.*

Kori, S. (2013). *Toward Adoption of Building Information Modelling in the Nigeria AEC industry*. MSc, University of Salford, Manchester.

Laiserin, J. (2002) "Comparing Pommes and Naranjas", *The Laiserin Letter*, December 16.

Laiserin, J. (2003) "Graphisoft on BIM", *The Laiserin Letter*.

Laiserin, J. (2008). Foreword to Eastman, C., *et al* (2008), *op cit*, p.xii

Lee, G., et al. (2012). *Business Value of BIM in South Korea (English). SmartMarket Report. Bedford, MA, McGraw Hill Construction". Analyticstore.construction. com.* Retrieved 24 October 2018.

Lincoln H. F. and Syed M. A. (2010) *Modern Construction: Lean Project Delivery and Integrated Practices,* CRC Press.

McKinsey & Co. (2015). wiodąca, globalna firma doradztwa strategicznego i operacyjnego http://mckinsey.pl. Retrieved 23 October, 2018

NBS National BIM Report 2016. *Thenbs.com*. Retrieved 24 October 2018.

Odudu, W.O. (1991) Estate Surveyor and Valuer in property development process, Paper presented at the 21st annual conference of the Nigerian Institution of Estate Surveyors and Valuers at Durbar hotel, Kaduna 24-28 April.

Ogbuefi, J. U (2002). *Aspects of Feasibility and Viability Studies.* Enugu: Institute for Development Studies

Ring, A. and Dasso, J. (1985). *Real Estate Principles and Practices (10th ed.).* New Jersey: Prentice Hall, Inc.

Ruffle S. (1986) "Architectural design exposed: from computer-aided-drawing to computer-aided-design" Environments and Planning B: Planning and Design 1986 March 7 pp 385-389. Abstract

Sawhney, Anil et al. (2014). *State of BIM Adoption and Outlook in India (English). RICS School of the Built Environment, Amity University. Noida, Uttar Pradesh" (*PDF). Retrieved 24 October 2018.

Shapiro, G. F. (2014). *Setting a Standard in Building Information Modeling. Architect Magazine. www.architectmagazine.com.* Retrieved 24th October 2018.

Utiome, Erezi, Drogemuller, Robin, & Docherty, Michael (2014). "BIM-based lifecycle planning and specifications for sustainable cities of the future : a conceptual approach"

Van Nederveen, G.A., Tolman, F.P. (1992). *"Modelling multiple views on buildings". Automation in Construction. **1** (3): 215–24.*

White, J. (2015). "BIM mandate for transport projects in Germany confirmed for 2020". *BIM Crunch*. Retrieved 24 October 2018.

Wu, S.; Zuo, M.J. (2010). "Linear and nonlinear preventive maintenance" (PDF). *IEEE Transactions on Reliability. **59** (1): 242–249.*

Yuseni, W. (2013). Building Maintenance Management Preliminary Finding of A Case Study in ICYM. *ResearchGate GmbH*. https://www.researchgate.net/publication/2584240 19. Retrieved on 22 October, 2018