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ADAPTION OF STRUCTURED ANALYSIS DESIGN TECHNIQUES METHODOLOGY FOR CONSTRUCTION PROJECT PLANNING

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The construction industry has been heavily criticised by researchers and governmental organisations for its performance especially excessive delay. Ballard and Howell (2003) indicated that only about 50% of the tasks on weekly work plans are completed by the end of the plan week. This is a result of a lack of either effective project planning or effective production control. It therefore seems the traditional approach of planning is insufficient to meet the current demand and complexity of construction projects. This paper proposes to critically evaluate the adaptation of Structured Analysis Design Techniques (SADT) methodology as a tool for project planning. SADT which was further developed into IDEF (**I**ntegrated **Def**inition) techniques claims to be a complete methodology to provide the means of understanding complex production systems and aid the implementation of change. The use of this methodology has led to process improvement. The research uses a literature review followed by interviews with academics and practitioners to investigate their knowledge and understanding of SADT (IDEF0). The results of the interviews indicated that SADT (IDEF0) methodology is seldom known and used in the construction industry. However, this study indicates that SADT methodology appears to be an effective project planning tool. This study contributes to the limited project planning techniques in construction industry by exploring the possible adaption of SADT.

Keywords: planning, project control, project management.

INTRODUCTION

Project Management (PM) is claimed to have a very long history; however, its current form was adopted into the construction industry around four to five decades ago (CIOB 2002). This current form is through the publication of Body of Knowledge (BoK) in PM which mainly includes Project Management Institute (PMI), Association for Project Management (APM), Chartered Institute of Builders (CIOB) Code of PM, International Project Management Association (IPMA), Japanese Project Management Forum, and Australian Institution of Project Management (Maylor, 2010; Cleland and Gareis 2006). PM has truly become "boundary-less"—cutting across disciplines,

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functions, organisations, and countries (Cleland and Gareis 2006). The evolution of PM has been closely associated to the development of systems engineering in the US Defence and aerospace industry (Morris 1994, Kenley 2004). The US Defence, before the late 1960s, developed tools such as: Work Breakdown Structure (WBS), Critical Path Method (CPM) (similar to PERT), Network Diagram, and Gantt chart (originally developed in 1917 by Henry Gantt) as the main PM tools which are referred to as the conventional techniques (Mubarak 2005).

Morris (1994) argues that PM, despite its fairly long development and techniques of planning currently available to the general practitioner, is often insufficient to the overall task of managing a project successfully. Koskela (1992) also argued that poor planning occurs because traditional planning techniques fail to support work flow of teams or materials which leads to suboptimal flows. Sweis *et al.* (2008) argue that, despite the current advantage of technology and understanding of PM techniques, construction projects still experience delays.

In the late 1980s, the US Air-force introduced a programme for Integrated Computer Aided Manufacturing (ICAM). The ICAM programme identified the need for better analysis and communication techniques for people involved in improving productivity. As a result, a series of techniques known as IDEF techniques were developed including IDEF0 which was adapted from SADT (IDEF0 1993). Prior literature claims great benefits in performance and productivity have been realised by the use of IDEF0 methodology (Later, SADT and IDEF0 are used interchangeably) in many industries. However, despite IDEF0 aiding better comprehension of engineering systems as they becomes more complex (IDEF0, 1993) it is little known and seldom used in construction. The question is asked whether IDEF0 can be adapted to enhance construction project management as a tool. Therefore, this study critically reviews IDEF0 model as a planning tool in the construction industry.

RESEARCH METHODOLOGY

This study is based on a comprehensive literature review of construction PM, focusing on planning and control, and SADT (studies on IDEF0). The research identified the delays and the causes, as the slogan "time is money" is globally acknowledged.

A qualitative approach was chosen because the research aim was to assess the understanding and knowledge of SADT/IDEF0 application. The use of a qualitative approach aids in focusing on perspective and expert experiences. (Bryman and Bell 2011). A personal (face to face) semi structured interview was utilised. Owing to the qualitative nature of the research carefully selected people were chosen to be interviewed. A total of thirty interviews were carried out comprising fifteen academics and fifteen practitioners in the field of construction. These groups were chosen so that both ends of the industry were covered. The interviewees were senior members of prominent companies and academia in the UK with significant experience. During the interview, the participants were asked about their knowledge and understanding of the SADT/IDEF0 model. The interviews were carried out to a point that desired data saturation was achieved.

CONSTRUCTION PROJECTS

According to Agyekum-Mensah (2012), "a construction project is the production of unique artefacts, normally using multiple disciplines, generally relating to Architectural, Engineering and Building; examples include civil engineering and building works such as roads, bridges, dams, railways and building works (new,

refurbishment and conversion)". Atkinson (1999) ascertained construction projects are continuously described as failing. Despite the advanced technology and project management techniques available to the practitioners, construction projects experience delays (Sweis *et al.* 2008). Sambasivan and Soo (2007) describe the delays in construction projects as a universal problem. This has led to many empirical studies on delays in both developed and developing economies (See table 1). Conclusions from many studies cite the fragmented nature of construction projects, lack of communication, management and financial problems as principal causes.

Hamzah *et al.* (2011) conclude that, the improvement of delay is not only limited to the consideration of technical factors, but also to issues of PM. Sambasivan and Soo (2007) concluded improper planning is the most likely cause of delay followed by poor site management. According to Sweis *et al.* (2008), responses from both consultants and owners ranked poor planning as the main cause of delay. Jongeling and Olofsson (2007) claim that only 15-20% of the time of a Swedish construction worker is spent on direct work due to lack of planning. The importance of planning is highlighted by Ballard and Howell (1998) who indicated that when planning reliability is above 50%, this will save 30% of labour consequently reducing project cost. Despite all the advances in PM theory and practice, construction project success is still below 40% (Hartman and Ashrafi 2004).

Table 1: Construction Delays observed in Literature

Authors	Delay observed	Country of study
Conlin & Retik (1997)	Overrun on 52% of projects	UK
Zwikael *et al.* (2005)	Overrun on 5% of projects	Japan
	Overrun on 30% of projects	Israel
Assaf *et al.* (2006)	30% completed on schedule (70% overrun)	Saudi Arabia
Ballard & Howell (1998, 2003)	Between 35 – 60% of weekly work regularly completed as planned	UK, USA
Odeh & Battaineh (2002)	Roads – actual to planned 160.5%	Jordan
	Building – actual to planned 120.3%	
Al-Momani (2000)	Public Project 81.5%	
Frimpong *et al.* (2003)	Groundwater construction 75%	Ghana
Aibinu & Jagboro (2002)	Building project 92.64%	Nigeria
Odeyinka and Yusif (1997)	Overrun 75% (every 7 out of 10)	
Mansfield *et al.* (1994)	Overrun as high as 342%	

CONSTRUCTION PLANNING

Planning and scheduling are often interchangeable; however, scheduling is one part of planning. Planning seeks to answer what, how, where, whom and when questions, schedule answers when. In fact the schedule is simply the itinerary (Mubarak 2005). Planning serves as a foundation for several related functions such as cost estimating, scheduling, project control, quality control, safety management. Ardit (1985) ranked planning on top of the list on potential for headquarters productivity of construction companies. Project Planning is an integral part of organisation strategic thinking and strategic management (Shenhar *et al.* 2001). Raymond and Bergeron (2008) argued that improvement in effectiveness and efficiency in managerial tasks are observed as a

result of better planning. Planning is vital to the role of a project manager yet there are increasing concerns over the failure of construction planning to achieve its goals (Laufer and Tucker, 1987).

Luiz and Hijazi (1993) discusses the network scheduling techniques used in the construction industry namely CPM, PERT, decision critical path method (DCPM) and the graphical evaluation and review technique (GERT). These conventional techniques have been criticised as ineffective by construction management researchers. There are two main disadvantages of using CPM and PERT in the construction industry. One is the emphasis on finding an optimal solution based on the shortest project duration, which involves minimising resources or cost. The other is the limited emphasis placed on input modelling (Lutz and Hijazi 1993). Birrell (1980) discussed extensively the limitations of CPM in his study, *Construction Planning – beyond critical path (CPM)*. Laufer and Tucker (1987) established that only 15% of CPM/PERT users deem these techniques as very successful.

Another planning tool available to the construction industry is the line of balance (LoB) technique. The line of balance concept comprises a graphical plot representing cumulative production versus time. Arditi and Albulak (1986), refer to the Line of Balance technique as a "linear scheduling method" since it is used for repetitive project. Arditi and Albulak (1986) argue that the origins are not clear; however, Arditi *et al.* (2001) suggested that this technique was developed by US Navy in the early 1950s during the Second World War for programming and controlling repetitive and non-repetitive projects. Arditi *et al.* (2001) argue that LoB technique was not fully developed and implemented by construction industry due to the immense popularity of network technique including CPM/PERT. Regardless, it has been applied to repetitive construction projects (Arditi and Albulak 1986), resource scheduling and highway pavement construction (Arditi *et al.* 2001). The contention is that the underlying theory of LoB is that the production rate of an activity is uniform. This is contradictory to general construction activities.

A radical investigation of construction problems from a theoretical stance concludes that the theory for construction project management as practice is obsolete and consequently, proposes TFV theory (Koskela 1992). Koskela later identified seven flow preconditions for the execution of construction task. Koskela and Howell (2002) argue that the conventional planning techniques fail to support flow of work and material since these techniques are based on conventional theory. Conversely, the Last Planner System® (LPS) was thus introduced by Ballard (1998) to bridge the gap in flow, planning and control. However, LPS is based on the limited application of methods such as CPM (Kenley 2004). Kenley (2004) argues that CPM, PERT and WBS are the mainstream planning tools due to the availability of relatively cheap and extremely powerful schedule software. Laitinen (1999) argues that the solution to problems in planning goes beyond the use of IT tools alone. Kenley (2004) claims lean construction proposes change in the traditional approach to construction management and demands a new approach to production planning but still depends on the conventional methodology of scheduling. It was further claimed that little effort has been put forward by researchers in solving the problem of physically creating flow. Existing techniques such as LPS emulate flow through management control systems which has resulted in the well-developed but proprietary LPS technique. Kenley (2004) suggests that it is the time to focus more effort on changing the way work is planned and managed in construction. In response to this, methodologies used

by the US Defence, the original reference point for PM is revisited and IDEF0 is reviewed.

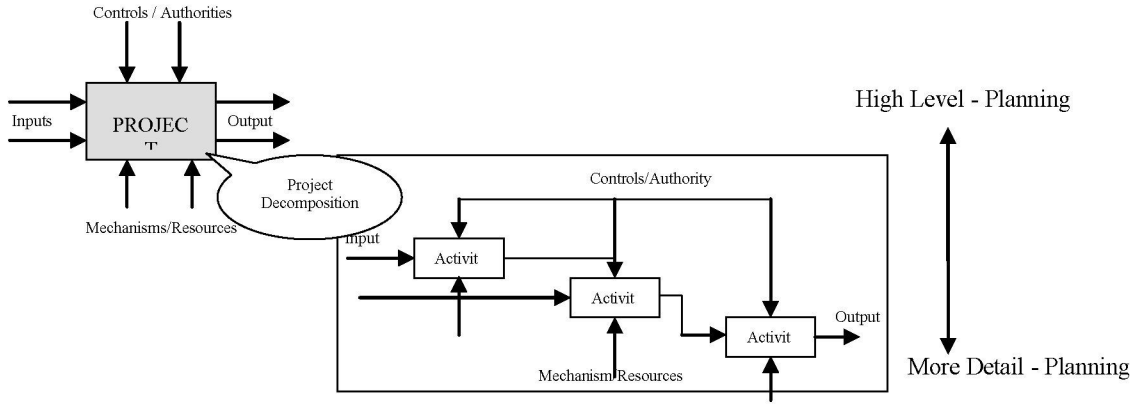
STRUCTURED ANALYSIS DESIGN TECHNIQUE (SADT)

Background

SADT was originally developed by Douglas T. Ross in the 1970s. Douglas was the chairman of SoftTech and head of Computer Applications Group at Massachusetts Institute of Technology (MIT). Due to his background in Mathematics, Electrical Engineering and Computer Science, his interest was in the software development process including methodology, theory, and tool development (Ross 1985). He is also renowned for the introduction of the Computer Aided Design (CAD), which was further developed and largely used in the construction industry (Ross and Ward 1968).

ICAM adapted the SADT activity model as IDEF0 which originated from the concept of Structural Analysis (SA) for Requirement Definition (RD). RD is to carefully assess, *why* a system is need, *what* system, *how* a system is to be constructed. Thus RD deals with three subjects: Context analysis (why), Function specification (what) and Design constraints (How). Through this RD led to the development of the Structured Analysis and Design Technique (SADT). SADT consists of both techniques for performing system analysis and design, and a process for applying these techniques in requirements definition and system development. Both features significantly increase the productivity and effectiveness of teams of people involved in system projects (Ross and Schoman, 1977). The two main representation of SADT are in the graphical techniques and the definition of personnel roles. The notation is simple, just boxes and arrows, where the boxes represent parts of whole in a precise manner, and the arrows represent interfaces between parts (see figure 1). Each box always has four arrows at the sides, that is, Input (I) Control (C), Output (O) and Mechanism (M), normally referred as ICOMs (Jongeling and Olofsson 2007). In 1993, the National Institute of Standard and Technology released IDEF0 as a standard for Function Modelling in Federation Information Process Standard (FIPS), (IDEF0 1993).

Figure 1: IDEF0/SADT Notation



Previous Application of SADT/IDEF

IDEF0 is a widely used technique for the structured analysis and design of systems. It is used in improving the productivity and communications in computer integrated manufacturing systems. IDEF0 has been applied successfully in hundreds of projects involving thousands of people in diverse industries as aerospace, telecommunications, and software development (Congram and Epelman 1995). Colquhoun *et al.* (1993),

Congram and Epelman (1995), Kim and Jang (2002), Presley and Liles (1995), and IDEF0 (1993) provide a comprehensive discussion on the use of IDEF0 in developing manufacturing-oriented models and its success. It has been discussed widely as a tool for business reengineering. Presley and Lies (1995) discuss applications of IDEF0 for design and specification of methodologies. The business process re-engineering modelling approaches reviewed by Gingele *et al.* (2002) conclude that only IDEF completely supports the criteria. Similarly, Cheng-Leong *et al.*'s (1999) development of manufacturing enterprise systems identifies some weakness in the traditional model approaches and advocates the use of IDEF techniques. Greswell *et al.* (1995) used IDEF0 to formulate and implement an improvement initiative in a major UK manufacturing company. Chin *et al.* (2006) used IDEF0 together with the colour Petri nets model to mould-making processes. Jongeling and Olofsson (2007) used IDEF0 model to describe their process to develop a model for workflow using 4D. Ohboshi *et al.* (1998) used IDEF0 to understand the medical emergency workflow. They concluded that the IDEF0 model holds promise as a method having the capacity of reproducing and designing systems like a Hospital Information System.

IDEF0 has also been discussed as a common mean of communication and it has also been applied to modelling of the construction process in Finland (Karhu *et al.* 1997, Laitinen 1999, Karhu 2001, Karstila 2003). Austin *et al.* (2002) adopted IDEF0 to represent the process in the development Analytical Design Planning Technique (ADePT). Generic Design and Construction Process Protocol considered the IDEF0 model for the 'as is' process because of the successful use of the model to represent processes (especially for Sanvido's Integrated Building Process Model (Kagioglou *et al.* 2000). Although it was claimed that the partners preferred to concentrate on the general principles of the process rather than the detail of the activities involve. Congram and Epelman (1995) established that IDEF0 methodology is flexible and it is recommended for adaptation for services. O'Donnell and Duffy (2002) adopted IDEF0 model as the tool for measuring and analysing design performance in engineering and construction design. They agree that, although IDEF0 does not explicitly represent the element of performance, it focuses on knowledge in design.

IDEF0 has been discussed extensively and used in industry, albeit not as much in the construction industry. However, none of studies have explored it as project planning technique. Nonetheless, the basic problem which drove development of SADT (IDEF0) as stated below is no different from the problems associated with construction projects.

> "The assertion that "a problem unstated is a problem unsolved" seem to have escaped many builders…All too often, design and implementation begins before the real needs and system function are fully known. The results are skyrocketing costs, missed scheduled, waste and duplication, disgruntled users and endless series of patches and repairs euphemistically called "system maintenance" (Ross and Schoman 1977)

The hypothesis is if "planning should answer these questions, *what* should be done (activities), *how* should activities be performed (method), *who* should perform each activity and with *what* means (resources) and *when* should activities be performed, and IDEF0 was developed for these questions", then IDEF0 is suggested to be an effective planning tool. Ross and Schoman (1977) explicitly stated that SADT/IDEF0 is for planning, managing, and assessing. Colquhoun and Baines (1991) found IDEF0 to be a powerful tool that offers a number of features which makes it easy to apply and most importantly to understand.

RESULTS & DISCUSSION

The result of the interviews shows that none of the interviewees had prior knowledge about IDEF0 or SADT. However, after its introduction to them by the first author, they found it to be simple and useful technique laudable to explore within the construction industry. The result was none after the first twenty interviewees therefore, additional ten were carried out which was the same results.

It must be acknowledged, however, that some participants questioned the desire of the construction industry to adapt to change. In as much as the construction industry has been criticised for lack of innovation and its conservatism approach, Sturges et. al., (1999) argues that, although the construction industry has adapted to change over the years, it is slow to drastic change. Consequently, IDEF0 has some commonalities with the existing accepted techniques; however, it is founded on different conceptual basis. The philosophy of IDEF0 model is, since there is a project then, there are processes and each process should have the Inputs, Controls (Constraints) and Resources (Mechanisms) to generate an Output.

The construction process is ambiguous, fragmented, and involves a significant number of participants. This affects the effectivity of planning construction projects. Although it is suggested that there is no one correct method for planning construction projects, there is a guided approach to achieve project objectives through effective planning. This planning approach should increase production by improving communication and the production process, which is the strength of using IDEF0 (Kuiak *et al*. 1993). Laufer and Tucker (1987) argue that CPM/PERT cannot be supplanted since better methods are unavailable. However, the US Defence who developed these conventional techniques sought to increase their productivity and later developed IDEF0. Yet, the construction industry has failed to explore its adaptability. This study identifies the following reasons for the adaption of IDEF0 for project planning:

- IDEF0 is completely general and applicable to any situation because it is unlike mathematical or logical methodologies or even programmes. IDEF0 methodology does not solve problems but provides tools that allow people to understand express manipulate and check problem elements (Ross 1985).
- The concept of IDEF0 can be used to illustrate the seven flows of Lean construction with the ICOM mode (see figure 2), where Inputs denotes, previous tasks and components and materials, Control denotes construction design, space and external conditions, Output the completed task, and Mechanism denotes workers and equipment.

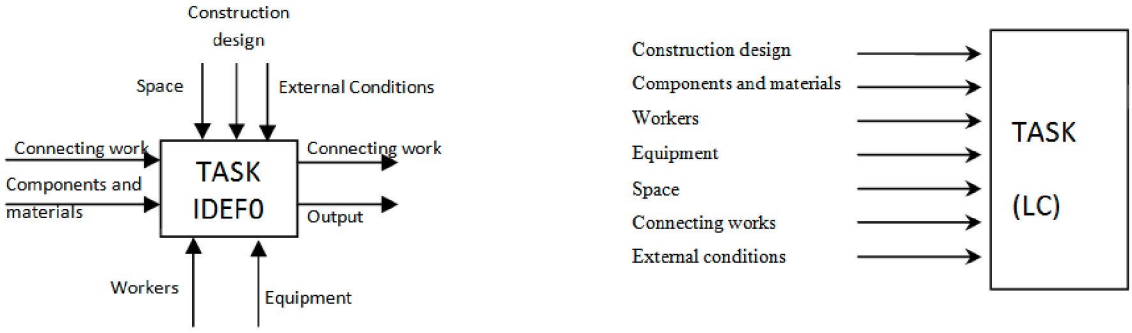


Figure 2: *Representation of Koskela's seven Flows in IDEF0*

- Using IDEF0 is relatively easy and is user friendly (Greswell *et al.* 2005)
- IDEF0 is a top-down design method which helps in dividing the project into deliverables or work packages and critically links the activities together. The connections between boxes indicate flow of control, information, objects or anything that can be described with noun phrases.
- IDEF0 promotes collaborative planning, thus, ensures planning efficiency is high for production. Nevertheless, it could be time consuming
- Use of IDEF0 benefits from communicating common understanding of the complex project to team. Therefore, IDEF0 increases productivity by improving communication and the production process (Kuiak et al., 1993)
- IDEF0 methodology incorporates the following for project management: WBS development, Task assignment, procedure definition, flow and communication. IDEF0 relates the activities in the production flow. The output of a preceding task is not necessary an input of the sequential task but could control or influence that activity.
- The use of graphical portrayal is a powerful means of representing the deliverables and how they connect or link with each other.
- It is well-tested and proven, through many years of use in many industries.

Barriers to implementation of IDEF0 in construction

In spite of the established use of IDEF0 in the US Airforce, manufacturing, computer and aerospace industries, it is seldom known and used in the construction industry. This could be due to the following:

1. *Lack of Knowledge:* Academics and practitioners of construction industry seldom know about IDEF0 or SADT methodology
2. *Limited exploration:* Some researchers in construction management suggest IDEF0 is used in the analysing of "as is" processes while other consider it is for IT programmes.
3. *Software distraction:* The shift of attention to extensive use of software for planning based on the traditional planning concepts. However, Laitinen (1999) advocates that the current problems in the construction industry cannot be solved with IT alone.

CONCLUSION

IDEF0 methodology is general and therefore could represent any process or procedure of planning and control. IDEF0 aids in understanding the process through its visual representation of the flow of activities. These will benefit from communication, resource and scope management, and common understanding for the project team.

This research established that IDEF0 is little known and seldom used in the construction industry; however, it is suggested that IDEF0 has the potential for adaptation for project planning and control. In addition, it could be used for project control since it explicitly takes into account all the seven flows and their management. Additionally, IDEF0 take into account the eighth flow (the common understanding). IDEF0 could be used for high level as well as detail project planning. It takes into account the input, control and mechanisms required carrying out a task to achieve the required output. This opposes the conventional technique of input to give output. Another inherent advantage of IDEF0 is its ability to assess the performance, efficiency and effectivity of an activity as discussed in O'Donnell and Duffy (2002).

The concept of IDEF0 as reviewed and discussed demonstrates the potential for adaption as a project planning technique and the critical evaluation of its implementation forms part of on-going research by the authors.

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