AN INTEGRATION OF CONSTRUCTION SITE LOGISTICS & ASSOCIATED VEHICLE MOVEMENTS TOWARDS A SUSTAINABLE CONSTRUCTION

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ABSTRACT

This paper presents a conceptual framework to integrate three different key areas; routing of external construction logistics; site-layout planning and site resource planning to achieve an effective and efficient logistics system. Studies in logistics management have suggested that the productivity gains can be achieved, particularly if the construction processes are planned from logistics perspective (*Agapiou et.al 1998)*. The logistics planning required an accurate scheduling of materials required to be delivered as per the conditions laid down by the site layout and site resource planning. Many researchers have paid a lot of attention in managing the total supply chain and internal logistics systems. However, external construction logistics, which has not been studied in detail plays a crucial role in developing an efficient integrated logistics system. The key focus of this study is to understand the role of external transportation system; material flow; resource planning; and how to mitigate the environmental impact of construction logistics activities on the surrounding areas. This paper describes an integrated conceptual logistics framework for timely delivery of material from manufacturer to the construction site. The development of a software tool based on this framework will allow the logistics planners in improving the productivity and sustainability in the building processes. This will result in an improved delivery efficiency and reliability; reduced fuel and delivery costs; a reduction in inventory levels via just in time deliveries. A qualitative research analysis strategy has been considered at the initial stages of this research study.

KEY WORDS

logistics, construction site coordination, transport planning, material flow control, scheduling.

INTRODUCTION

On a construction site, logistics by its very nature is an extremely dynamic process as different kinds of materials and assembly components arrive and the site evolves into a finished building. Transport accounts for 10-20% of construction costs *(BRE report 2003).*

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The Confederation of British Industry has estimated that annual cost of road congestion to the economy is £20 billion. Construction vehicles accounts for a significant proportion of this congestion, and construction sites suffer inefficiencies as a result of unreliability of deliveries. The BRE (2003) report has indicated that if transport and logistics were dealt with more efficiently, trades people would be free to concentrate on their core activities, with a potential of reducing staff and materials costs by at least 15%The subject of logistics is often overlooked in favour of the more popular topics of strategy and tactics. Military history reveals that we are in danger of not fully appreciating its importance. The role of logistics manager is becoming more and more crucial to tackle these uncertainties on a big project. The aim of this research paper is to develop an integrated efficient logistics routing system within and outside a construction site. The reminder of the paper provides a background to the logistics and material management concepts on the basis of process modelling.

DYNAMIC LOGISTICS PLANNING IN CONSTRUCTION

Logistics is defined as the part of the supply chain that plans, implements, and controls the efficient, effective flow and storage of goods, services and related information from the point of origin to the point of consumption in order to meet customers' requirements (Council of Logistics Management 1999). The process of pre-fabrication, pre-assembly, standardisation and modularisation are proceeding at a pace and its influence on logistics practice can be noticed in almost every aspect of the industry. The early incorporation of logistics guidelines and flow of information of materials will lead to a better logistics planning on site *(Sobokta & Czarnigowska 2005; Agapiou et. al 1998).* An overview of an integrated dynamic logistics system is illustrated with the IDEF0 diagram in fig 1. IDEF0 is a standard diagram for modelling the decisions, actions, and activities of an organisation or system *(NIST, 1993).*

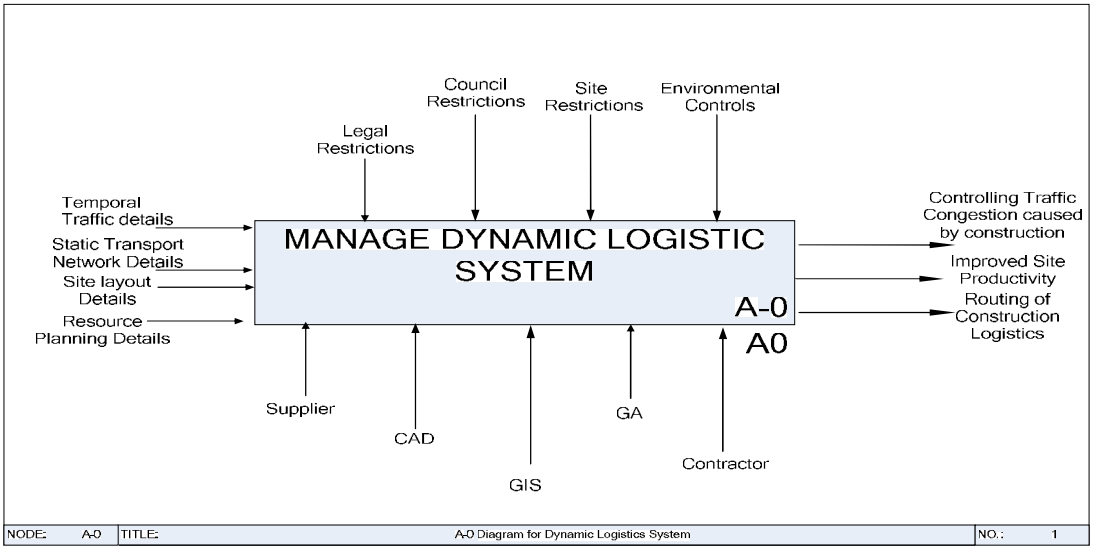

Figure: 1 Dynamic Logistics System

The process model in fig 2 describes how a dynamic logistics system can be used to integrate the external traffic movements, site layout plan and construction site resource planning to have a sustainable construction. The dynamic logistics system is divided in to three phases. Each of these phases is reviewed in detail. Route & schedule logistics activities mainly focuses on external transportation systems and tries to select an optimal traffic network system to deliver the material at site. Site layout is a schematic plan representing the location of plant, equipment and materials on site. Site layout planning is complex and comprises of a variety of factors like; site location, nature of the project etc. (*Tam et al. 2001)*. Planning an optimum site layout is very crucial, especially when the project duration is short. Construction site resource planning focuses on how to integrate the detail WorkPlan requirements (based on Last Planner Methodology) with external logistics and site layout system to have an integrated dynamic logistics system to combat the site requirements.

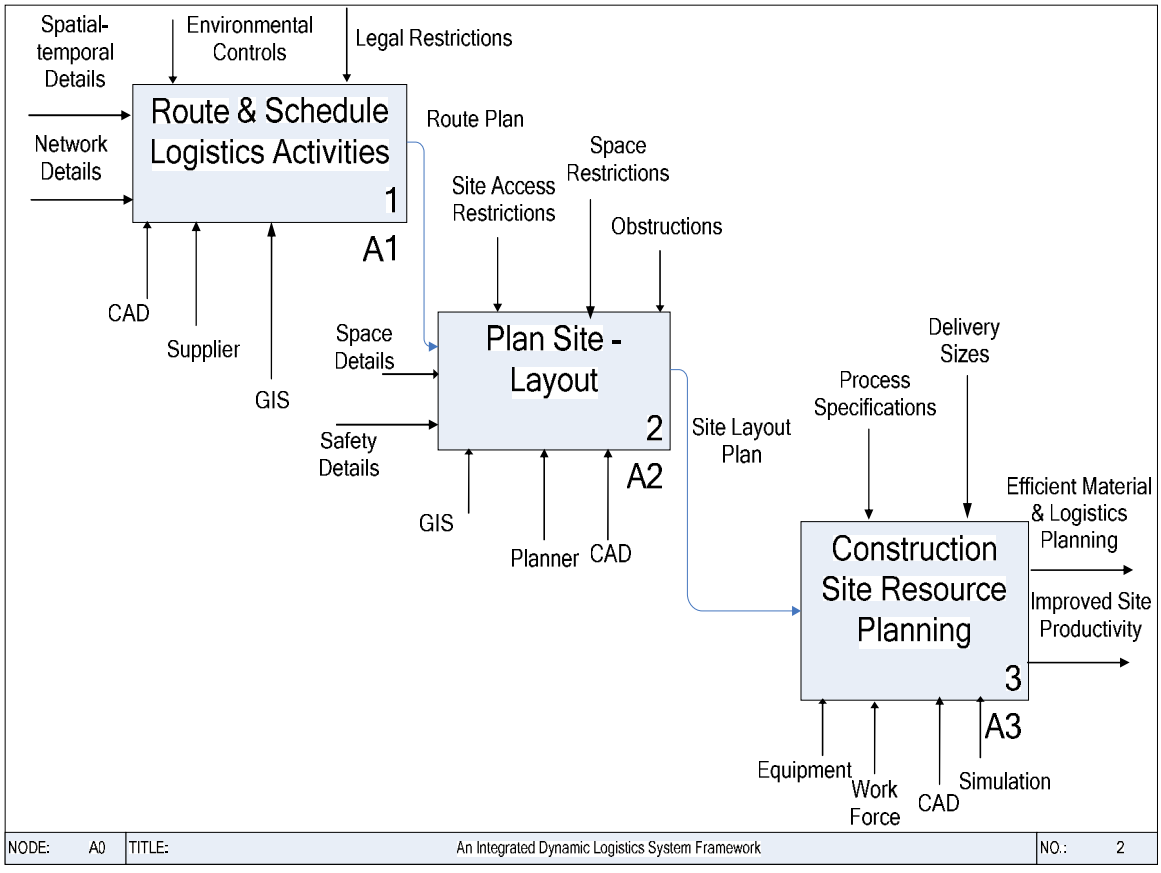

Figure 2: IDEF0 for an Integrated Dynamic Logistics Framework

External Logistics Planning

Logistics, the process of making sure that labour and materials are at the right place, at the right time, is a vital part of any construction project. On a construction site, logistics is by its very nature an extremely dynamic process as different kinds of materials arrive and the site evolves into a finished building. The important component of an external logistics system is routing and scheduling of construction logistics activities to minimise its effect on traffic system and environment. In order to deliver the material on site an external logistics system requires an accurate prediction of vehicular routes and route travel time. *Miller et.al* (1999) suggested that time-critical external logistics management include static transportation network data and temporal origin-destination trip departure data. They used geographic information system (GIS) based decision support system to predict network flow at detailed temporal resolutions to select a shortest path required for a shipment to reach its destination by a given deadline. The three important factors considered in this phase are spatial-temporal details, environmental control and council restrictions. The parameters grouped under spatial-temporal factors that can affect the timely delivery of material are road-closure, diversions, road layout, construction, weather and accident. The parameters grouped under environmental control are safety regulations, noise level, vibration control, speed restrictions, and load capacity restrictions (size of the delivery). Figure 3 represents the IDEF0 diagram for the process of routing and scheduling of external logistics system.

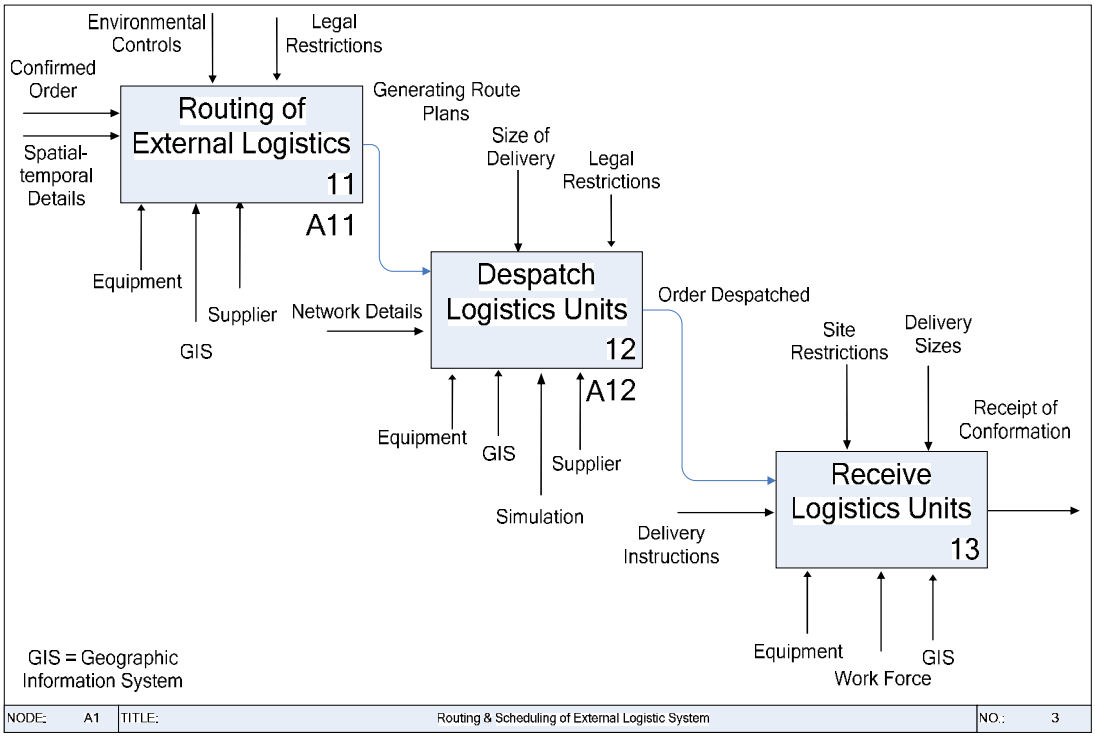

Figure 3: IDEF0 for Routing & Scheduling of External Logistics System

Site Layout Planning

Site layout is a part and parcel of materials management which determines the location of off-loading, location of the storage spaces, protection of the materials and movement of materials to construction areas *(Pheng and Hui 1998)*. The aim of this phase is to select the optimum path for material routing by proper analysis of site facilities, space and safety within the construction site. Many researchers have pointed to the importance of site layout in increasing site productivity, minimising the travelling time and maximising the space utilisation *(Hans 1984; Foster 1986)*.

The method utilised for site layout planning include operations research techniques, artificial intelligence techniques (AI), CAD-based approaches, genetic algorithm (GA), and simulation techniques. Many researchers *(Elbeitagi & Hegazy 2001; Sobotka, A 1999; Tommelein 1994; Mahdjoubi & Yang 2001; Cheng and O'Connor 1996; Tawfik & Fernando 2001)* have done lot of work in developing a computer-based system in planning site layout facilities. *Dawood & Marasini (2001)* has suggested that artificial intelligence and simulation techniques are potential techniques to solve problems having multiple objective criteria. This phase is divided in three stages i.e. site initialisation; site modelling and site optimisation. Site initialisation is the process of planning site facilities (vehicles, building components, temporary facilities etc) on the site. Initial site layout can be constructed using GIS or CAD data. CAD package will be used in developing the geometry of the site layout. GIS will be used in developing the relationships between the site facilities and surrounding site features. Site modelling is the process of evaluating the site layout on the basis of site safety and available site spaces. Site optimisation is the process of generating the optimised routes using above mentioned information and genetic algorithms. Figure 4 shows the process of site-layout planning using the IDEF0 diagram.

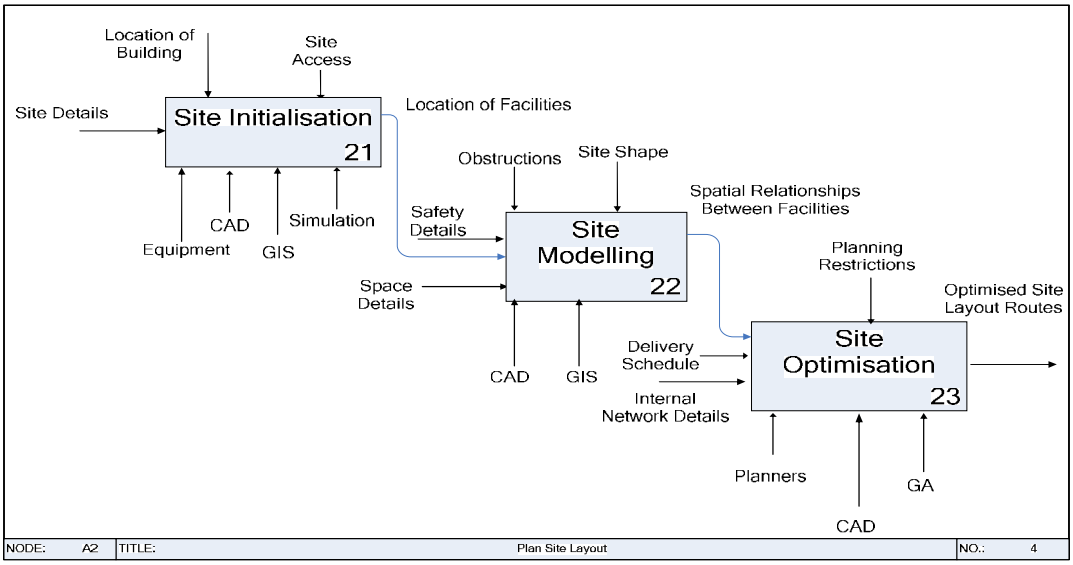

Figure 4: IDEF0 for Site Layout Planning

Construction Site Resource Planning

In reality, the construction project under consideration might suffer from various delays like; harsh ground conditions, bad weather, client change orders, etc. These uncertainties will ultimately increase the project execution time. *Mahdjoubi and Yang (2001)* proposed that material management systems should be integrated with project planning and scheduling. The aim of this phase is to integrate the detail WorkPlan requirements (based on Last Planner Methodology) with external logistics and site layout system to have an integrated dynamic logistics system to combat site requirements. As explained by *Choo et al. (1999)* that WorkPlan are the detailed scheduling of work packages, which identify the constraints, release work packages and allocate resources. A work package is a sub-element of a construction project. Work package is a planning process that requires a detailed understanding of scope of the work and its constraints. Figure 5 shows the process of construction resource management using the IDEF0 diagram.

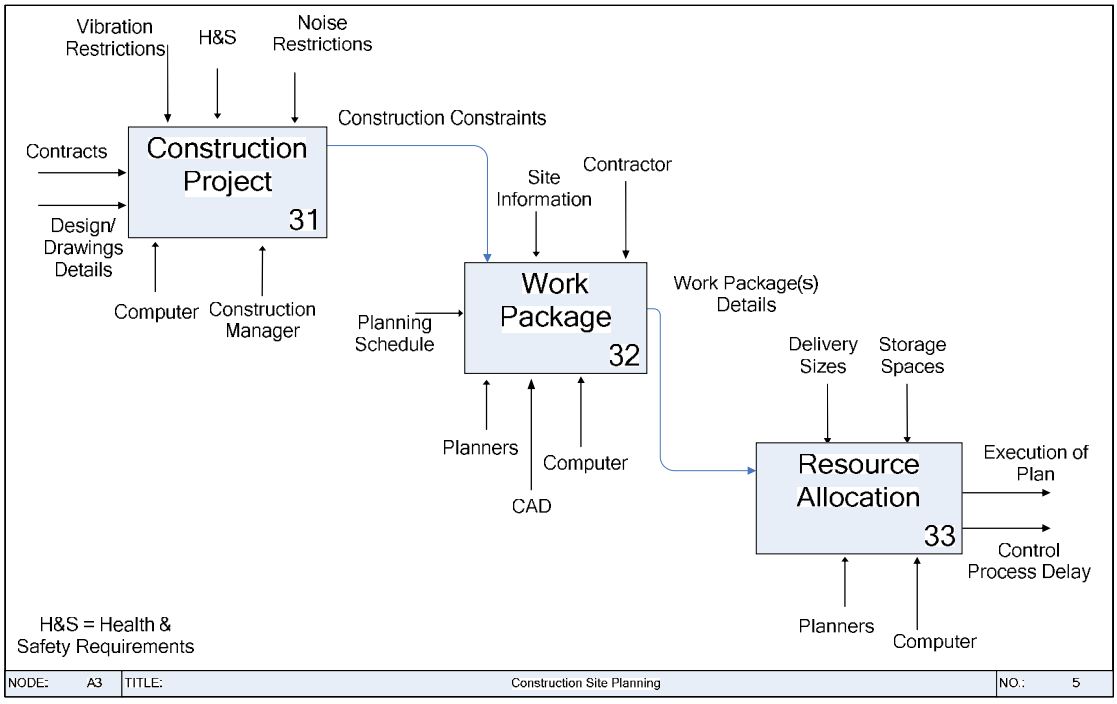

Figure 5: IDEF0 for Construction Site Resource Planning

Despite these research developments, little work has been done in integrating the internal logistics system with external logistics system on construction sites. So, there is a need to develop a software tool that can support logistic managers and planners in their decision making process based on an integrated logistics routing system.

FUTURE RESERCH ACTIVITIES

In addition to the ongoing process of collecting wide range of site constraint parameters affecting a logistics system from past and active projects, this research will include to develop a computer-based system using computer-aided design, geographic information systems, genetic algorithms and simulation techniques to select the best available route.

CONCLUSIONS

This paper has described the basic integrated dynamic logistics concept and development of a conceptual logistics framework to manage movement of materials from manufacturer to the construction site. Few companies in construction are using well defined flow model or electronic communication technology when compared with manufacturing industry. Additionally, there is a lack of transparency in costs, trust and confidence within the supply chain. The advance planning and design aspect of projects are generally inadequate. So, industry needs a well defined efficient and integrated dynamic logistics system that will assist logistics planners in improving the productivity and sustainability in the building processes. Organised loading/unloading times will lead to lower costs, reduce site congestion and lead to improved site space utilisation. It is anticipated that an integrated logistics system will improved delivery efficiency and reliability; reduced fuel and delivery costs; a reduction in inventory levels via just in time deliveries.

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