# Location Breakdown Structure (LBS): a solution for construction project management data redundancy

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#### Abstract

The evolution of construction Project Management (PM) practices is linked to the development of PERT, a network based control system for product completion. PM practices aim to control cost and time based on a hierarchy work breakdown structure (WBS). The work to be done on a project is defined in work packages. However, for construction projects, current use of WBS creates a significant amount of data redundancy, because all of the work is location specific. This paper argues that location is a more appropriate unit of analysis and thus the obvious conceptual framework for construction projects. Built environment production is explained in the Location Based Management System (LBMS). The LBMS components are unified and location allows the integration of many data mechanisms into a knowledge-base for a project. Location provides the container for all project data and is used as the primary work division through a location breakdown structure (LBS). The LBS provides the opportunity, used in conjunction with the WBS, to limit excessive location specific data repetition. This paper outlines the application of a WBS/LBS matrix as one method for improving construction project productivity. The WBS, once freed of location-repetition, can more efficiently describe the work being done which permits increased administrative productivity.

Keywords: Productivity, Location Breakdown Structure, WBS/LBS matrix; location-based thinking

## 1. Introduction

Work Breakdown Structure (WBS) is an essential component of Project Management (PM). The commonly accepted definition for WBS is: "...a product-oriented family tree subdivision of the hardware, services and data required to produce the end product which is structured in accordance with the way the work will be performed and reflects the way in which project costs and data will be summarised and eventually reported" (Kerzner, 2007). This product breakdown definition is also reflected in the Project Management Standards (PMI-PMBOK, 2013; ISO 21500, 2012; PMI-WBS, 2006; SA-AS4817, 2006;).

Interestingly, there is very little literature underpinning this definition (Kenley & Harfield, 2013). WBS emerged as a tool to ensure scope management from the earliest days of formalising processes for the management of projects. The WBS created a framework for network planning (CPM) and thus was a method for driving task allocation in the network planning of projects in the 1950s and 60s. It has subsequently been accepted as a fundamental aspect of PM with very little challenge (Weaver, 2007).

Project Management practice is grounded in the use of the WBS, a tool used to detail the work required to produce the final product or deliverables. This 'structure' is a way to define, or scope or contain the many inter-dependent actions and resources required to manage a project to completion. Thus, 'structure' is a well-entrenched concept in relation to project definition.

According to Archibold and Villoria (1967), project definition equated to a WBS, with seven substructures: Project Organisation, Network Plan, Calendar Time, Estimating, Chart of Account, Funding and Authorisation Control, and Report. These sub-structures have become the basis of project administration processes. Systems theory indicates that these constituent parts must 'mesh' into an adaptive whole. However, in practice this is very difficult to achieve for construction management systems (Norman et al., 2008; Rad, 1999; Moder et al., 1983). This problem of integration must reduce productivity, especially in PM processes

Currently, there is a dearth of PM literature considering project breakdown structures from the perspective of data efficiency and reuse. This is surprising because data redundancy should be integral to the design and development of an efficient WBS. One of the dominant themes of database research and design in records management (Ismail and Jamaludin, 2009) and data management (Andritsos et al., 2004) is a concern with data efficiency by minimising data duplication. However, data repetition can be avoided in WBS to enhance activity-based efficiency. Location is known to be a significant component of the WBS of all construction projects and is a source of data repetition (Kenley, 2004; Harris & Ioannou, 1998). Therefore, location can be stripped out of WBS and integrated together in a breakdown matrix.

The Location-Based Management system (LBMS) described by Kenley and Seppänen (2010) is an integrated network of management system components potentially involving all stages of construction, from design through to completion. The system components are unified and location allows the integration of many data components into a knowledge-base for a project. Location is the

logical container for data which relates to the quantum of the project which enables efficient data quality limiting data redundancy utilising a location breakdown structure (LBS).

The balance of this paper focuses on data management efficiencies that are possible by focusing on location-based construction management techniques. Section two outlines the importance of articulating location for managing construction projects. Section three describes the features and advantages of a Location Breakdown Structure. Section four provides an outline of the differences between traditional and location-based project scheduling. Section five extends the concept of a project management breakdown matrix followed by the conclusion.

## 2. Construction: a location-based project

Construction projects, whether bridges, road or rail lines, high-rise or wide-rise buildings, all have one characteristic that is different from many other projects. Each of these involves products for the built environment and location is a major feature. All construction projects provide products for a specific location; often the actual construction takes place at that location. Thus, these projects are 'location-oriented', with location being both implicit and explicit for all construction management endeavours (Ibrahim et al., 2009).

Current PM practice is centred on managing a project through the WBS. The concept of WBS originates in network theory (Operations Research) as does much of the founding PM literature (Kerzner, 2007). The original purpose of WBS was to ensure product completion from a work perspective. The focus of the work perspective is on project completion as specified, within budget and on time. Definitions of the work to be done begins with project scope leading to project targets and deliverables calculated by methodologies for planning and control. The essential characteristic, location, of construction projects suggests the need to revisit PM basics in order to consider models that focus on location in managing construction projects data.

The Location-Based Management system (LBMS) described by Kenley and Seppänen (2010) is an integrated network of management system components potentially involving all stages of construction, from design through to completion. The system components are unified and location allows the integration of many data components into a knowledge-base for a project. This makes the LBMS rich in integrated data which parallels other initiatives such as BIM for integrated project delivery or the integrated project environments that are now emerging.

One important concept of LBMS is the Location Breakdown Structure (LBS). Utilisation of an LBS for construction projects, along with suitable project models and management strategies, can systematically improve project production efficiency of data. LBS is not a building information model (BIM) but rather a methodology for interacting with a BIM, placing demands on the BIM for both properties and characterisation (breakdown).

## 3. Location breakdown structure (LBS)

Ibrahim et al. (2009) found that the most frequently used decomposition criteria in the formulation of WBS for building projects are elements, work sections, physical location and construction aids. This indicates that location is embedded into the WBS hierarchy on construction projects. Indeed, Ibrahim et al. proposed a hierarchical decomposition of a building project based on these criteria. When they were doing their research, little was published on LBS. Ibrahim et al. noted that they were not aware of a standardised classification for the "location" criterion. They therefore simply adopted a classification based on floor level since this was identified as the definition commonly adopted by planners.

Location as the unit of analysis is at the heart of the LBMS. Location provides the container for all project data, and is used as the primary work division through a location breakdown structure (LBS)—rather than the more familiar work breakdown structure (WBS).

Location is the container for data which relates to the quantum of the project. The LBS is hierarchical so that a higher level location logically includes all the lower level locations. Each of the location hierarchies has a different purpose. The highest level is used to optimise construction sequence, because the structures of such sections are independent of each other and therefore it is possible to start them in any sequence or to build them simultaneously. The middle levels are used to plan production flow of structure (and often reflect physical constraints). The lowest levels are used for planning detail and finishes. This allows data to be collected at different levels within the hierarchy. The location contains the following types of data:

- Building objects or components such as elements and sub-systems
- Planned and actual building component quantities
- Building system production assemblies
- Planned and actual material costs
- Building system costs.

# 4. Scheduling a project

The Project Management literature, and indeed practice as defined in the Project Management Standards, considers projects as being capable of decomposition through hierarchical structures. Application of the reductionist concept of decomposition is the organising principle that enables the process of sub-dividing the total project into smaller parts. This process is carried out to ensure the smallest task is defined and is able to be managed within a complex system. The process of decomposition is based on a hierarchical tree through 'parent and child' segmentation of the total project (Stal-Le Cardinal and Marle, 2006). Each sub-division must fit into the defined project scope and completion deliverables. Thus, decomposition design can be from either a top-down or a bottom-up perspective, both based on rational choice theory (Weaver, 2007). To understand the different methodologies for decomposition, it is worthwhile recapping PM development.

### 4.1 Activity-based method

The lowest WBS level of decomposition usually contains 'work packages' (Norman et al., 2008). The work packages generally form the link to subsequent processes, most particularly scheduling. Detailed time scheduling will break work packages down further into component activities, a process that may involve further hierarchical decomposition.

Activity-based scheduling is the current dominant scheduling technique. It was first developed in the 1950s, but owed much to the theory of scientific management (Taylor, 1911) and the visualising techniques of Henry Gantt (1919). He used these to manage infrastructure projects such as the Hoover Dam in the USA. Development of modelling projects through a schedule for planning and controlling work continued in order to take advantage of the new technology of the 1950s, the computer. DuPont initiated research in 1956 which led to the seminal model developed by Kelley and Walker (1959). The underlying maths provides a topological map of discrete activities joined by logical relationships. Each individual activity is considered free to move in time as long as it maintains the logical relationship with its predecessors and successors. Such a model suits any project where activities are completely discrete and have no structural correlation with other activities.

Kelley and Walker (1959) coined the term Critical Path Method (CPM) because in the projects they were modelling, critical activities were easily identified. The technique relies on the construction of a logical network of activities. The term 'activity-based' describes this methodology because the underlying epistemology is that a project may be modelled solely with individual packages of works (activities) and their logical relationships. The focus of the method is therefore on the activity as the container for project data, and the logical network is constructed by linking activities. The methodology is elegant and powerful, and has clearly enabled a rich environment for improving project performance (Norman et al., 2008).

#### 4.2 Location-based method

The LBMS was also borne within scheduling theory development (Kenley and Seppänen, 2010). Location-based scheduling is another methodology, but it is based on tracking the continuity of crews working on production tasks. This was done originally using graphical techniques, designed by Karol Adamieçki in 1896 (Marsh, 1975). However, as PM developed, location-based scheduling was considered outside of the mainstream engineering perspective in the US (Kolltveit et al., 2007). On the other hand, managing large complex construction projects data can be considered from different perspectives. For example, the logistics issues of building the 102 storey Empire State Building in 1930-31. A LBMS suited the complexity of 102 stories, constrained building site delivery, massive quantities of steel & stone from various different sources, plus 4000 workers. Location was also an important issue for USA Defence requirements of the 1940s and 50s which supported further development of location-based scheduling (Battersby, 1964).

The underlying epistemology for a location-based method is that a project may be modelled by including individual packages of works into a connected whole entity called a task, which represents the aggregation of activities in multiple locations. This family of methods involve repetitive activities

which Harris and Ioannou (1998) gave the generic term *repetitive scheduling method* (RSM). Russell Kenley (2004) coined the term *location-based scheduling*, considering it more appropriate and descriptive of the character of the methodology.

Location-based topological models may be constructed by linking both tasks and activities through a complex network of logical relationships. While in its basic form the methodology is largely graphical, modern methods have shown that it is possible to incorporate the full range of CPM logical relationships, both within and between tasks. Furthermore, the presence of tasks and locations allows much more powerful relationships to be built providing much greater power and flexibility for modelling construction projects.

What emerges from this discussion is that traditional project management embeds location in the WBS of construction projects whereas location-based management of construction establishes an LBS to manage project data. This raises the question whether or not PM theory, and WBS decomposition, can benefit from the use of LBS in some direct way.

# 5. New project breakdown matrix: WBS/LBS

Turner (2000) considered the potential of 'breaking down' a project from a different perspective. He suggests a Product Breakdown Structure (PBS) which is indicative of project objectives and a major structural container focused on responsibility and personnel in an Organisational Breakdown Structure (OBS). He suggests the WBS is actually a two-dimensional matrix (PBS X OBS) formed by the intersection of the two hierarchical breakdowns at corresponding levels of breakdown. Thus, the WBS is actually a 2D container for managing a project.

This important concept, considering the intersection of two differently focused breakdown structures, has received little attention by PM researchers (Kenley and Harfield, 2012). Yet potentially this concept of the 2D model as a container reveals a significantly different view of the WBS from the conventional definition of a hierarchical tree (Kerzner, 2007; Colenson, 2000). This matrix-like view provides a hint for alternative ways to break down project data providing the possibility of productivity gains through more efficient data management.



Figure 1: Project Breakdown Matrix

The key to changing the way we think about the management of projects is to change the way we decompose their structure. The problem with current practice is that the WBS is a single hierarchy structure which must meet conflicting demands. It is therefore proposed that breakdown structures strip out location from the hierarchy to create a matrix, as shown in Figure 1.

Breaking down a project in this way clarifies the advantages of location-based management. The WBS, once freed of location-repetition, can more efficiently describe the work being done. Then the repetition of each level of the WBS across multiple locations can be handled by the matrix using the LBS providing a mechanism for removing data redundancy. In fact, this technique can be applied in any situation and using any technical platform, it does not need to be a specific location-based tool.

The opportunity is to use location-based techniques in any management system to strip out the location hierarchy from the WBS. An example of the application of this opportunity is demonstrated by Moine (2012). He argues for a 3D WBS as represented in Figure 2. This 3D model consists of:

- Activities (ABS, Activity Breakdown Structure), "Install / build", as defined actions or processes;
- Products (PBS, Product Breakdown Structure), "components", that is to say, equipment, materials or engineering works to finer levels of the tree. On the upper floors, the PBS is composed of functional systems (SBS, System Breakdown Structure); and
- Areas (GBS Geographical Breakdown Structure), "somewhere", which can be geographical or functional according to the phases of the project.

Then the WBS results from the crossing of GBS, PBS and ABS (Moine, 2012). One of the key benefits of this approach is that schedules can be rapidly built, by exploiting repetition of activities.



Figure 2: 3D WBS (from Moine, 2012)

Breaking down a project in this way clarifies the advantage of location-based management. The advantages of a LBS/WBS matrix are:

#### • Production efficiency

Managing resources to ensure continuous production tasks flow through locations.

#### • Finer hierarchy structures

Waiting time can be buried in a schedule due to the use of an implied location breakdown with too course a structure. Mapping production using an LBS can make these issues much easier to spot and enable the waste to be removed or converted into a buffer.

#### • Process efficiency

Current administration of projects is becoming increasingly onerous because of the increasing amount of data that can be easily transferred. The Project Breakdown Matrix enables repetition in processes and forms to be stripped out of the administration systems.

## 6. Conclusion

This paper has argued for an acceptance of the primacy of location in construction project management (PM). Currently project management administration is overloaded with data, because the simple fact of location repetition within a variety of processes. The Location-Based Management system (LBMS) described by Kenley and Seppänen (2010) is an integrated network of management system components potentially involving all stages of construction, from design through to completion. The system components are unified and location allows the integration of many data components into a knowledge-base for a project.

Location is the unit of analysis of the Location-Based Management system. Because location provides the container for all project data, and is used as the primary work division through a LBS rather than the more familiar WBS. This paper has suggested a matrix of WBS and LBS for improving project productivity. If all PM systems extract the LBS from the WBS, then data redundancy will be reduced. Indeed, the mere act of doing so forces recognition of the role of location and empowers the project manager with additional tools and techniques.

A Location Based Management System (LBMS) provides the conceptual foundation for mechanisms that provide data management efficiencies through identification and utilisation of location in work package tasks. Because LBMS articulates the primacy of location for construction, it provides a framework for location-based thinking. For example, schedule compression can be very difficult to achieve. Often it is not possible to remove time from a schedule when problems have arisen. However, location-based thinking can reveal the existence of parallel work opportunities which enable overlapping work. Whilst a good manager might realize this, location-based thinking makes the opportunity much easier to identify.

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