Linear Scheduling as a Data Visualization Tool for Construction Progress Analysis – A Case Study from the Panama Canal Expansion Program

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**EXTENTED ABSTRACT**

Due to an increasingly competitive environment and the thriving of more ambitious and complex projects, construction managers have been forced to enhance their project management skills to achieve successful results in terms of cost, quality and time. In order to do so, the implementation of innovative scheduling tools that allow project management teams to evaluate multiple scenarios or risks at the planning stage of a project becomes a crucial factor to foresee and mitigate conflict situations. Moreover, the quest for and use of such tools should not be limited to the planning stage, since there is also a need to identify and mitigate issues during the execution phase and maximize the efficiency of the Project Manager’s decision-making process by providing a clearer panorama.

This tendency requires more focused scheduling tools that need to be chosen depending on the type of project at hand. The critical path method (CPM) is the most utilized scheduling tool in the construction industry worldwide. Nevertheless, there are types of projects in which CPM’s usefulness decreases because it becomes complex and difficult to use and understand, becoming impractical and losing its core purpose. Alternative scheduling tools designed for specific types of projects can prove to be more suitable and useful than CPM solutions. Here is where linear scheduling takes importance.

Traditionally, linear scheduling is used as a visual representation of a construction schedule for projects that follow a linear production path with a large number of repetitive activities such as: highways, bridges, pipelines, dams, high-rise buildings, rail construction projects, among others. The linear schedule displays work sequence information similar to that on a CPM schedule or Gantt chart in a way that is easier and more intuitive to interpret. It is a quite versatile method that can be adapted to various applications in a construction project. Depending on the purpose, either for planning construction works, following-up the progress, or forensic analysis for claim defense strategy, the scheduler has the responsibility to adapt the linear schedule layout to show what she considers priority information that is valuable to facilitate interpretation and understanding for stakeholders.

Many situations may arise during the execution of a project that could lead to delays, some of which could be caused by force majeure or fortuitous events which cannot be reasonably avoided or foreseen by the contractor or the owner, or in other terms, are beyond the control of the parties. However, in most of cases, interruptions are produced by actions and/or inactions on either the Contractor’s or the Owner’s side. Although most standard forms of contract include provisions to define and attempt to allocate responsibilities in-advance in case of delay, in the vast majority of occasions, the parties are not able to settle amicable agreements through these mechanisms. This often leads to Contractors filing a claim which results in costly and prolonged disputes during execution or even after project completion. In construction projects, this situation occurs often and delay claims are very usual. Depending upon the complexity of the project, delay claims could represent significant amounts of money in disputes, in which the required assessment of events entails comprehensive scheduling analysis for both parties, owner and Contractor, to defend and sustain their positions. For certain type of projects, Gantt charts become tedious to interpret and communicate, it is then when alternative scheduling methods such as linear scheduling can be explored to identify key events or other situations that actually caused the delay when real and objective contractor’s performance is depicted.

This paper explores the potential for broadening the applications of this tool for critical decision-making analyses by displaying and correlating information that would be less apparent otherwise. For that purpose, a case study illustrating how forensic linear scheduling was actually implemented as a data visualization tool to correlate the causes of delay is offered as an example of the technique. The project in which this innovative tool was applied is the construction of the Borinquen Dam 1E construction, a 5 million cubic meter (6.54 million cubic yards) earthfill dam procured by the Panama Canal Authority as part of the USD 5.2 billion Panama Canal Expansion Program. The case study demonstrates how as-built information can be introduced into a linear schedule format to perform forensic claim analysis and support. Variables such as daily rain precipitation, geological conditions at the dam’s foundation and unattended available areas to work are displayed and clearly identified in a single linear schedule to graphically depict the project’s as-built condition based on daily reports. By using a contractually binding source of information such as the project’s daily reports, an objective representation of the project facts is obtained by this method, which allows to potentially resolve disputes.

This paper’s contribution to the body of knowledge is to provide innovative applications of the linear scheduling method to graphically depict data that is not readily available when using traditional means, increasing the effectiveness of decision-making and improving the way construction projects are managed. The potential for application of this tool includes most maritime-related projects such as dams, piers, docks, navigation channels and locks among others. The case study demonstrates the benefits that this tool provides and illustrates how the concept works even for highly complex projects with several factors and dimensions of complexity.

One limitation of the concept presented in this paper is that, in the authors’ opinion, it should not be used as a single solution for project scheduling in lieu of the CPM method unless the project is simple enough to be handled graphically. The intent of this study and the recommendation of the authors is to implement it as an auxiliary tool that provides powerful analytic capabilities that, added to the best practices in CPM scheduling, provides a significant information gain that will to give a competitive advantage over traditionally-focused tools. This limitation is currently mitigated with the use of specialized tools available in the market that effectively integrate both methods to provide a solution for all needs when used properly.