Using the Project Schedule for Variation Analysis

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Abstract:

The general conditions of the construction contract define provisions for managing and negotiating variations in time, cost and/or quality of the constructed facility. These provisions, such as those from the FIDIC Red Book, place the oneness of substantiation for such variations on the contractor. With increased cost and subsequent cost variations, ample substantiation may be provided by receipts and detailed construction cost estimates. With time effects, however, adverse impacts of variations are harder to quantify due to the influence of network logic on the project completion date. This paper will examine predominant network scheduling tools, such as Gantt charts, network diagrams and cost curves, and will discuss the advantages and disadvantages of each for support of variation claims.

Introduction:

The construction process has one universal constant – change! There are always variations which arise as projects progress. These variations are due to a large number of factors, including changing owner requirements or desires, differing physical conditions on the site, obscure contract documents or details, and so on. Variations are so common that general conditions of the contract documents have well defined procedures for negotiation of the terms of the variation process.

In the United Arab Emirates, the general conditions for the construction process are routinely guided by the documents developed and published by the International Federation of Consulting Engineers (FIDIC). There are three different structures for the FIDIC Conditions of Contract:

- The FIDIC Red Book: The Conditions of Contract for Construction – For Building and Engineering works designed by the Employer. This form of the general condition covers traditional, design-bid-build contracts.
- The FIDIC Yellow Book: The Conditions of Contract for Plant and Design Build – For Electrical & Mechanical Plan & for Building and Engineering Works Design by the Contractor – Plant and Design Build Contracts
- The FIDIC Silver Book: The Condition of Contract for EPC Turnkey Projects

The process of variations will be examined using the 1999 FIDIC Red Book, which accommodates the traditional design-bid-build process whereby design and construction elements are separated. This traditional DBB structure of project delivery is diagrammed in Figure 1.

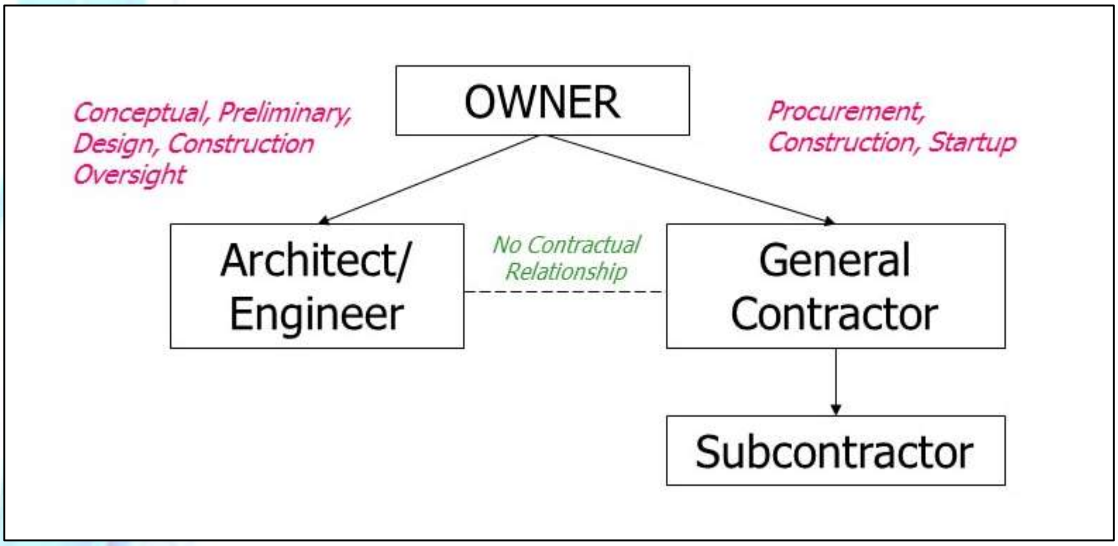

Figure 1: Organization of Parties for Project Delivery in the Traditional Design-Bid-Build (DBB) Structure

The traditional form of construction project delivery is driven by the project owner whom initiates the project and is tied to all life-cycle elements from concept to completion. Frequently, the owner contracts with an architectural and/or engineering design professional to assist with conceptual and preliminary design. Such steps within the project life-cycle assist with development and refinement of concepts in order to focus the design professional for detailed design. Through this detailed design process, contract documents, such as the plans and specifications, are generated.

Upon completion of the design, the tendering process is initiated and a contractor solicited, often through a competitive bid process. Tendering consultation may be given to the owner by the design professional or may be separately contracted to a consulting engineer. In either case, such parties are contracted to the owner and do not have a contractual relationship with the contractor. A separate contract is awarded to the General Contractor (G/C) whom may utilize subcontractors as an extension of their workforce for completion of the work activities required. The subcontractors enter into separate contractual arrangements with the G/C and are not contractually obligated to the owner.

The tendering process involves:

- Establishment of construction milestones, such as the start-date and completion date, and establishment of bidding terms (i.e. What documents are required to bid? How are the bids received?, etc.)

- Solicitation of contract bids. This involves announcement of the bid and distribution of the bid package.
- Receipt of bids and proposals from interested contractors and subsequent bid evaluation.
- Contract award.

This process is outlined in the forward provided for the FIDIC Red Book – 1999. The letter of acceptance and letter of commencement formalize the contractual agreement and start the time clock for the period of construction respectively. As long as there are no delays, the construction process continues towards completion within the time allocated for project completion.

Within the contract terms, the general contractor has the responsibility of "commenc[ing] the execution of the Works as soon as is reasonably practicable after the Commencement Date and then [to] proceed … without due expedition and without delay." [FIDIC Red Book, Section 8.1]. This requires the contractor to complete all responsibilities within the contractual completion time. The owner receives assurance of the contractors plan within the detailed time program, which includes project schedule information, specification of subcontractors and methods, inspection schedules, etc.

As previously specified, one constant in construction is that there will always be change. Change often lead to delays or cost overruns, which involve variations in the contract terms which may be attributable to either the owner or the contractor. There are many different causes of delays, including but not limited to the following:

- Modifications of the owners' demands and desires
- Uncertainty in the contract documents (plans or specifications)
- Unforeseen events (natural hazards)
- Unexpected site conditions
- Unrealistic assumptions by the contractor in planning
- Changes in the economy, such as pricing differences and supply/demand issues
- Labor and productivity variations

Variations can be issued at any time by the engineer working on behalf of the owner. These can be issued in response to a direct instruction or at the request of the contractor. Irrespective of the triggering event of the variation, the contractor, once the variation is finalized, is responsible for executing the work. The process for variation negotiation is outlined in the FIDIC Red Book and is summarized in the following section.

Variation Causes and Substantiation Requirements in the FIDIC Red Book

A variation may be looked at in terms of a change to the contract terms. These contract terms may impact either the cost, the schedule (time) or the quality of the project. As elaborated upon, the changes may result from:

a. "Changes to the quantities of any item of work included in the contract (however such changes do not necessarily constitute a Variation),

b. Changes to the quality and other characteristics of any item of work,

c. Changes to the levels, positions and/or dimensions of any part of the Works,

d. Omission of any work unless it is to be carried out by others,

e. Any additional work, Plan, Materials or services necessary for the Permanent Works, including any associated Tests on Completion, boreholes and other testing and exploratory work, or

f. Changes of the sequence or timing of the execution of the Works."

The contractor is prohibited from making any altercations to the design without approval of the variation from the Engineer.

When a variation is negotiated and finalized, the contractor, "shall keep contemporary records to substantiate any claim." Such records are required to substantiate time, cost and quality claims and variations, which are coupled factors. The tools and techniques to substantiate the claims on these factors are often distinct. Cost and quality are fairly straightforward when considering substantiation of a claim. For instance, if a variation is initiated for higher-quality finishes, information from material suppliers can be assembled to document the difference in material and installation costs for the higher quality. Time impacts, however, are more complicated as the pertinent issue is the contract completion date and variations must be assessed in relation to the critical path. Thus, time impacts must be resolved and substantiated through examination of the impact on the project schedule.

Tools for Scheduling

Primary tools for project scheduling include the Gantt chart (Figure 2), the CPM or Network Diagram (Figure 3) and the Cumulative Cost Curve (Figure 4). The Gantt chart shows the activities within the network on a time-scale where activities are designated by color-coded bars indicating the criticality of the activity and the activity path. This technique is very intuitive and is easy to understand by all parties throughout the construction process. The Gantt chart, however, is limited when showing activity relationships and when calculating network parameters, such as the various types of float.

Network diagrams, often referred to as CPM diagrams or Precedence diagrams, provide a basis for examination of activity relationships and activity logic. Typically, network diagrams do not show activities on a time-scale and this makes the precedence diagram more specialized and less intuitive to the untrained observer. From an engineering perspective, however, the network diagram is more rigorous showing the logical interrelationship between the activities and providing the structure for calculation of significant scheduling parameters, such as the activity floats.

The Gantt chart and network diagrams are effective tools for time management, however, they are not sufficient. Any effective schedule must also be used for control of the project in terms of costs in addition to time. Resource histograms and cumulative cost distributions are commonly utilized tools for cost management. The cumulative cost distribution, shown in Figure 4, is often referred to as an S-Curve and demonstrates the planned cash-flow for the network under consideration. Cumulative cost distributions for actual costs can then be compared to the as-planned cost distribution to evaluate progress.

Each of these tools have purposes in the planning process and the information generated is interrelated and complementary. None of the tools, however, would be effective for variation analysis without using them for contract control. This requires coupling the techniques with an effective data collection and control process, such as that identified by the payment structures discussed in the FIDIC Red Book. Progress can be recorded and then used for assembly of progress payment requests. The information can further be used to benchmark performance against the baseline or as-planned schedule. When placed on a Gantt chart, a rapid visual inspection of the as-planned versus baseline activity durations can give an indication of whether individual activities have been completed on-time. The Gantt chart will also show a projected project completion date assuming retained logic and future activities progressing as planned. The network diagram permits recalculation of floats but does not provide a visual representation of the actual conditions versus the planned, baseline schedule.

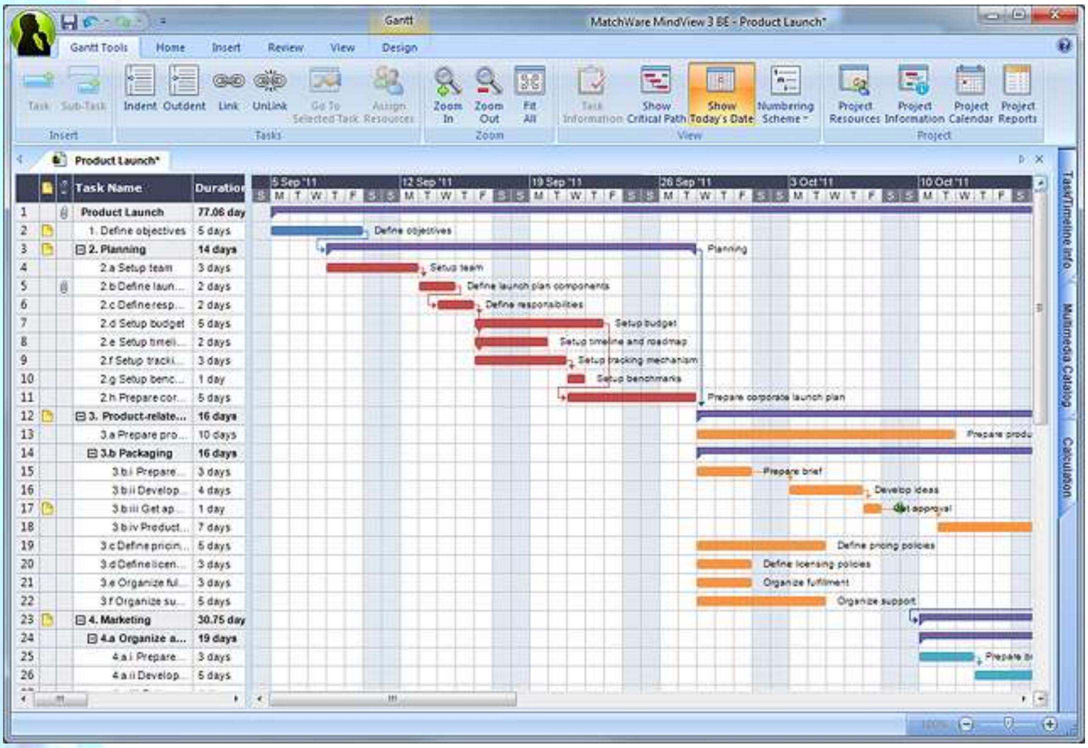

Figure 2: Sample Gantt Chart [source: matchware.com]

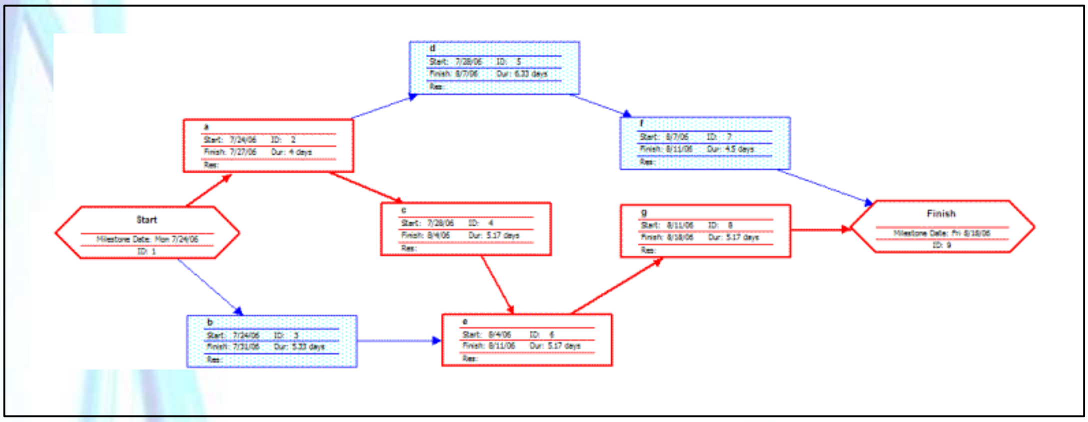

Figure 3: Sample Network or CPM Diagram [source: Wikipedia.org]

Neither the Gantt chart nor the Network Diagram are effective at projecting schedule and cost variations for the project based on current performance. For these purposes, the Earned Value Approach particularly useful. The Earned Value Method is based on the cumulative cost distribution. This is shown in concept in Figure 4. The PV curve can be considered as the as-planned cumulative cost distribution. The quantities actually expended and the cost actually incurred may vary from the as-planned quantities and costs.   Actual costs and earned value curves are generated based on these quantities and costs in order to quantify both the cost and schedule variances, when compared to the as-planned conditions. The cost and schedule variances can then be used to develop a projection for the overall project cost and time, assuming that actions continue to progress at the same cost and rate. This projection can be useful in determining remedial actions to get the project back on track.

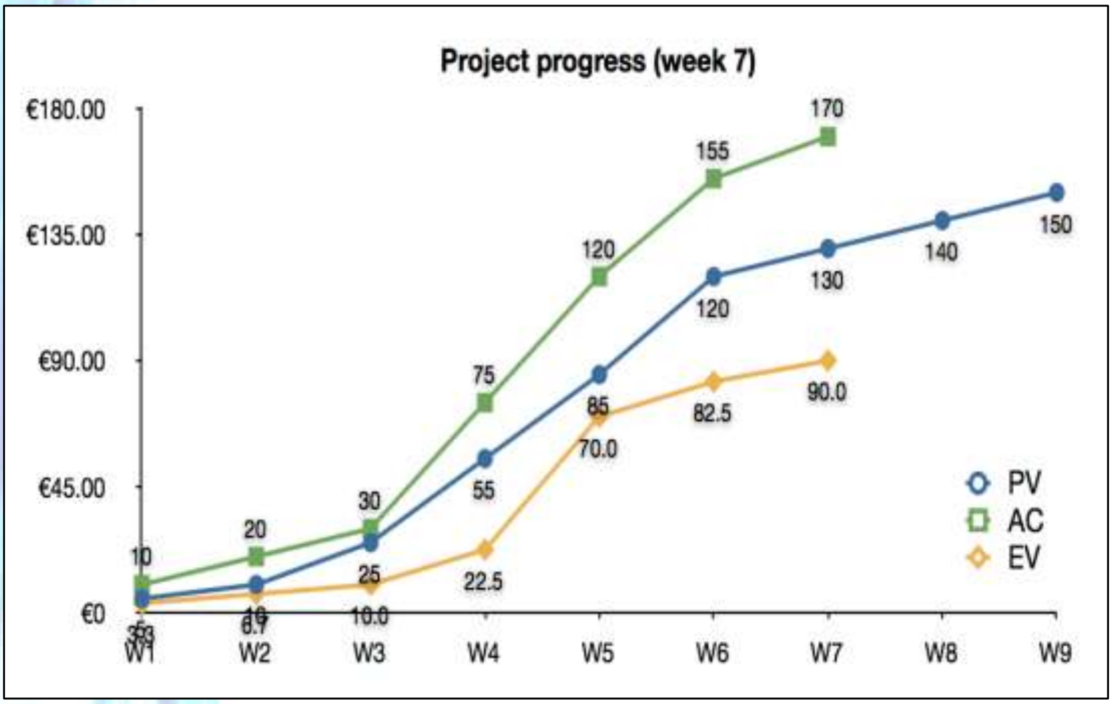

Figure 4: Sample Cumulative Cost Distribution and Earned Value Curves [source: pmknowledgecenter.be]

The Use of Project Scheduling Tools for Variation Analysis

It has been shown that the contractor has the duty to substantiate claims and variations. In terms of costs, this challenge is straightforward. When coupled with time, however, justification and substantiation becomes increasingly complex and must be examined using project scheduling tools. Consider for instance, the situation where variations are due to owner initiated changes. In this case, the contractor can ascertain the additional cost, can determine any additional time required, and can develop an impact of the overall impact of the variation on the project completion date. This can be used as a basis for negotiating the variation with the Gantt chart, network diagram and cumulative cost distribution comparisons used to graphically convey information and substantiate the claim.

There are situations, however, where it may be difficult to substantiate the impact of the variation. This occurs when the activities are non-critical and variations do not exhaust the float. In this case, additional costs are incurred but the critical path is unaffected; therefore, additional claims for time are unsubstantiated. The contractor may argue that the loss of float should be economically valued as the loss of opportunity, which is likely to be argued by the owner, which can lead to disputes. This question ties into the long-running debate of whom owns float, which continues to be actively debated among construction management professionals and legal representatives.   This question remains contentious and there is no clear, non-situational answer on the validity of such variation claims. Should the contractor pursue such a claim, earned value analysis projections may enable quantification of the economic effect in terms of the overall project and would be encouraged for use as a basis of discussion.

There are many other tools that could be used, such as the Project Evaluation and Review Technique (PERT), Linear Scheduling Methods and other techniques which could be further used to support claims in specific situations. The applicability and effectiveness of such approaches would undoubtedly be dependent on the type and complexity of the project and the uncertainties instituted by the variations.

Conclusion:

This paper examined predominant network scheduling tools, such as Gantt charts, network diagrams and cost curves, and briefly discussed the advantages and disadvantages of each for support of variation claims. The examination focused on the traditional design-bid-build process focusing on the owner and general contractor relationship. The types and causes of variations were briefly discussed and the responsibilities of the contractor for substantiation of claims as per the FIDIC Red Book were outlined. Variations were seen to be a function of time, cost or quality changes. Substantiating cost claims were demonstrated to be considerably straight-forward when compared to the time impacts, which are a function of the network logic. For such conditions, the network critical path impacts must be evaluated. Gantt charts and network diagram when coupled with cumulative cost distributions were shown to have significant application in supporting variation claims. Such tools, however, do not negate the questions of the ownership and valuation of float, however, which remains a hotly contested issue internationally. Significant additional work can be done in this area to evaluate existing techniques and to develop new tools for substantiation. Research efforts can further develop the concepts to evaluate the efficacy and applicability of using such techniques for variation analysis.

References;

Bunni, Nael G. *The FIDIC Form of Contract Book: The Fourth Edition of the Red Book*. BSP Professional, 1991

FIDIC, Conditions of Contract for Construction (First Ed. 1999). For Building and Engineering Works designed by the Employer. General conditions; Guidance for Preparation of Particular Conditions; Forms of Tender, etc. FC-RA-A-AA-09

Halpin, Daniel W., and Bolivar A. Senior. *Construction Management*. Hoboken, NJ: Wiley, 2011. Print.

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