Infrastructure projects planning and scheduling: challenges and opportunities

More robust scheduling methodologies should be used to overcome the challenges facing the Qatar construction industry

By Hassan Emam and Peter Farrell

Projects in many industries suffer from time and cost overruns. Construction projects, in particular, have a bad reputation for frequently exceeding their budget and falling into delay. The most frequent cited cause of delay is attributed to ineffective planning and scheduling of projects.

The ambitious infrastructure plans announced by the Qatari government will magnify the impact of the time and budget overrun, if projects are not planned and controlled effectively and efficiently. This article discusses the shortfalls in current scheduling practices and recommends alternatives.

The vast majority of construction planners use the Critical Path Method (CPM). Moreover, on most large projects in Qatar, the use of CPM is mandated in contracts.

CPM is an activity and network-based deterministic time optimization technique that was developed in 1959. This definition reveals three aspects of the technique, that lie in the terms "Time Optimization", "Network" and "Deterministic". The anatomy of these three terms will be defined to illustrate the problems lying behind them.

Time optimization

Usually planners and construction practitioners define the critical path as the sequence of activities that cannot be delayed if projects are to finish on time. The main problem lies in the time orientation of the technique and ignoring other factors that affect projects.

These factors can be summarized as uncertainties, objectives (i.e. cost optimization and resource leveling), constraints (i.e. resource availability), or more advanced factors that can be traded-off such as time, cost, quality, safety and environment.

Network-based technique

Construction projects in general and infrastructure projects in particular have repetitive operations. Examples of types of projects with repetitive operations are: roads, highways, tunnels, pipelines and railways. The aforementioned project types with their specific repetitive properties are usually referred to as "location-based projects".

Hassan Emam

Hassan Emam MBA, PSP is a planning and scheduling professional with diversified experience in construction. His has a diversified industry experience in variety of projects such as residential, commercial, airports, bridges, marine, and railway. Currently, he is PhD candidate at the University of Bolton. he2mpo@bolton.ac.uk

The repetition in such projects emphasizes the cons of modeling them using CPM. The current practice of producing schedules is breaking down projects by location (every constant distance), creating sub-networks of activities for each location then creating relationships between the sub-networks.

The described process leads to extremely large schedules that require a lot of professional time to maintain. Consequently, project planners' attention is diverted to managing schedules rather than managing projects.

Deterministic scheduling

The term "deterministic" refers to certainty in schedule assumptions. In real-life scheduling, there is no certainty about assumptions. In reality, the vast majority of assumptions are uncertain. Examples of uncertainty are: productivity rates of equipment and manpower, delivery dates for materials, weather, and laws and regulations.

The traditional CPM method ignores the aforesaid uncertainties and deals with all assumptions as deterministic. In some instances, CPM schedules are subject to schedule risk analysis; however, this is a separate process done in isolation of schedule preparation.

Recommended practice

In the previous section of this article the weaknesses of traditional CPM scheduling methods are investigated. It is the intention of this section to propose solutions to the earlier identified disadvantages.

Scheduling techniques are not limited to CPM.

There are a plethora of methods and algorithms developed to satisfy different scheduling requirements, e.g. Program Evaluation and Review Technique (PERT), Line-of-Balance (LOB), and Linear Scheduling Methods (LSM).

The decision to be made is to select the proper scheduling method that fits your purpose. There are decision-making algorithms that are suitable for trade-off problems.

Trade-off scheduling problems consider conflicting objectives such as time and cost. Whenever time is reduced cost will consequently increase. The schedule objectives can be to minimize or maximize any of the following: time, cost, quality, safety, and interruption time.

Meanwhile, trade-off will be a combination of two or more of the aforesaid objectives.

Constraints Satisfaction Problem (CSP) is scheduling problems that seek feasibility rather than optimality. The regular constraints can be project completion date, resource availability (i.e. manpower, equipment, budget and materials), resource leveling, and resource allocation problems. The selection of the scheduling methodology shall be mandated by objectives and constraints in the scheduling problem.

Location-based scheduling technique

The problem of network scheduling in repetitive projects as discussed earlier can be resolved by changing the schedule representation.

Several studies have established that using alternative methods to the traditional methods can be more efficient and effective. These studies proposed two methods: LSM and LOB.

LSM is derived from LOB with minor differences in representation. The LOB is usually used in non-linear projects with repetition such as high-rise buildings or housing.

Meanwhile, LSM is preferred in linear projects with repetitive activities. A sample of both methods is shown in Figure 1.

Considering Uncertainty

Uncertainties in schedules exist in almost every element. Productivity rates, manpower availability, activity duration, equipment breakdown and material availability are examples of schedule uncertainty. Dealing with uncertainty requires that we change scheduling methods from being deterministic to what is called stochastic (probabilistic) scheduling.

The uncertainties are accounted for by specifying a range of uncertain parameters in schedules. An example is duration, where schedules are computed with stochastic durations in a range such as optimistic, most probable and pessimistic.

These estimates are then used through different methods such as PERT, Monte-Carlo simulation, and chance constrained programming to calculate schedule completion dates along with a level of confidence.

Conclusion

Existing scheduling practices are naïve and cannot be used to manage complex projects effectively and efficiently. The shortfalls of current practice, identified in this article, should be considered a driver for change.

More robust scheduling methodologies should be used to overcome the challenges facing the Qatar construction industry. The adaptation of the proposed methodologies - among others that are not mentioned here due to space restrictions - can be a considerable opportunity for companies to gain competitive advantage over their rivals.

Dr Peter Farrell

Dr Peter Farrell MSc FCIOB, FRICS is a Reader at the University of Bolton. He supervises research and teaches in construction and commercial management. His industry training was in planning and quantity surveying, whilst most of his post-qualification work was as a contractor's site manager.

***Hassan Emam and Peter Farrell may be contacted on e-mails at: he2mpo@bolton.ac.uk and P.Farrell@bolton.ac.uk respectively.**

Figure 1: Line-of-Balance vs. Linear Scheduling representation