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A BRIEF HISTORY OF CONSTRUCTION SCHEDULES

Scheduling has always been an essential part of construction. Time and resources to complete projects are always limited. Scheduling techniques have advanced over the years to meet the demand for more complex projects delivered in the shortest time possible, with the highest quality, all for the lowest cost.

It was not until the First World War that simple bar charts were employed by the British army for planning military exercises. The construction of the Empire State building (which began in 1930 well before the invention of PCs or modern scheduling techniques), the tallest building in the world until 1972, was, itself, a marvel of scheduling excellence. The site in downtown Manhattan was so congested there were virtually no lay down areas. Expeditors at the materials' source had to arrange for delivery to coincide precisely with installation. Construction was elaborately planned and scheduled by Andrew J. Eken, chief engineer of the General Contractor, Starret Bros. & Eken Inc. The building's 58,000 tons of structural steel was erected in six months at the remarkable rate of 4.5 floors per week,¹ all without the aid of a CPM schedule or a computer!

For many years, schedules were prepared graphically using the simple bar

IF TIME IS ALWAYS OF THE ESSENCE, WHERE DOES THAT LEAVE SCHEDULES?

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chart (or Gantt chart). This time-scaled display of activities plotted as bars over a time line provides a good graphical portrayal for work schedules. It is still emulated by many scheduling software programs. The main disadvantage with the bar chart is the lack of an underlying logic for the plan, which is not shown on the chart.

This was generally the status of scheduling until the 1950s when the critical path method (CPM) was developed. The critical path method involves the development of networks that include both the identified activities and their logical dependencies. However, manually producing large networks was both time consuming and costly. With the development of cheap powerful computers, scheduling entered a new era. No longer requiring a team of people dedicated full time to scheduling a project, today's project schedules can usually be handled by one person and result in sophisticated graphical output. A word of caution, however: a schedule that is produced by one person in a vacuum, without input from those that will actually build according to the schedule, will be absolutely useless.

THE NEED FOR CONSTRUCTION SCHEDULES

There are traditional differences in opinion between owners and contractors on many issues. However both will agree that completing the project as quickly as possible is a common goal although for different reasons.

Simply stated, the owner generally wants to have a project completed quickly so that the facility can be put to use as soon as possible. There are circum-

stances in which an owner may not want to have a project completed earlier than planned for financial or other business reasons; in such a case the owner simply wants the project delivered on time.

The contractor, on the other hand, wants to complete the project as quickly as is economical because every day spent on site costs money. Furthermore, cash flow is the lifeblood of the contractor; without it he will not survive. Achieving the scheduled monthly progress helps the contractor to meet his cash flow requirements. In addition, the contractor does not usually get paid the full contract amount until the project is completed.

While owners and contractors have similar goals, they have differing needs and expectations from the schedule. Contractors will (or at least should) use the schedule primarily as a planning and management tool. The process of planning and scheduling the project includes determining the overall approach to the job, organising and planning of labour and equipment resources, materials purchasing and deliveries, sub-contract awards and prioritising key shop drawing submittals.

Owners, on the other hand, will use the contractor's schedule to monitor progress and most importantly to see when the job will be completed. In addition the schedule will help to plan and monitor cash flow requirements and determine when owner-supplied materials and equipment must be delivered to the site.

Construction projects continue to increase in size and complexity. So does the demand to build more quickly and economically. In 1982 (reprinted in

¹ Engineering News Record, "1931 Empire State Stands Tallest for Decades," Greatest Construction Projects, p. 16.

1992), The Business Roundtable issued a report entitled *Modern Management Systems, A Construction Industry Cost Effectiveness Project Report* [See: www.brtable.org] in which the authors state –

"The construction industry has been criticized, to a large extent justifiably, for its slow acceptance and use of modern management methods to plan and execute projects. Many people both inside and outside the industry view this as the primary cause of serious delays in schedules and large cost overruns that have plagued the construction industry in recent years. Yet there is no lack of modern, cost effective management systems that provide project managers with all the controls they need."

Owners are the ultimate beneficiaries of improvements in cost, schedule, and quality of their construction projects. But many owners do not seem to be aware of the economic payoff from the appropriate use of modern management systems, and therefore are unwilling to incur the costs of operating the system."

[Emphasis Added]

This report goes on to state –

"... a key factor in improvement is the relationship between the owner and the contractor, first in establishing target schedules, and then dealing with the changes which inevitably impact their strategies."

The Business Roundtable report places a lot of responsibility for leading the way and promoting the use of schedules on the shoulders of the owners. Owners are the "ultimate beneficiaries" of the process and should therefore be prepared to pay the costs associated with receiving those benefits.

The Associated General Contractors of America (AGC) has several publications dealing with scheduling. The AGC book, *Construction Planning & Scheduling*² published in 1997, examines scheduling from the contractor's point of view and states the need for planning and scheduling quite clearly –

"There is just too much at stake to undertake a construction project without a well thought out plan.

Without a plan, there is no way to schedule the required work, no way to track progress, and no way of deciding on corrective action when unexpected events occur. ... To illustrate the need for a plan, consider the general contractor that is awarded a contract for the construction of a commercial building with a project duration of 18 months. Further suppose that the general contractor estimates that the building's direct construction costs, excluding site overhead will be about \$20,000,000. If the contract duration is 18 months, the contractor has about 350 work days assuming no seasonal shutdowns. This means that, on average, the general contractor must put approximately \$57,000 of construction in place each work day."

There can be no question that time and money can be lost through poor project planning and scheduling. For example, lack of planning and scheduling can result in late delivery of crucial material and equipment to site. This in turn can result in delays, lost productivity and increased costs. Unscheduled delivery of material may result in costly double handling and increased storage costs. If the completion date of a project is delayed the owner and the contractor both suffer and risk incurring additional cost.

While there are obvious benefits to proper scheduling — and potentially saving money is a pretty compelling reason — why do many contractors not want to provide owners with a schedule? The Business Roundtable article above states that the owners are "...the ultimate beneficiaries of improvements in cost, schedule, and quality of their construction projects". Why do owners not seem willing to pay for the scheduling from which they will ultimately benefit? Over the years, we have heard many reasons for contractors not wanting to put the effort into a decent schedule and supply it to owners. Here are but a few examples:

- "Schedules are too expensive, if I include the cost of preparing a schedule in my bid I won't get the job."
- "It doesn't help me get the job done."
- "It takes too much effort to do it."
- "The schedule is not accurate, the job never seems to go the way it has been scheduled."
- "How can I possibly schedule a job when there are so many changes, right now I have no idea when the job

will be done because all we seem to be doing is dealing with changes."

- "The owner is only going to use it against me."

and an all-time favourite:

- "We've only been on the job for six months and the owner says we're seven months behind schedule, how can that be? HELP!"

As strange as it may seem, this final example illustrates a fundamental lack of knowledge about how to read and understand the important information contained in a schedule, and demonstrates a problem frequently encountered. There is generally a lack of proper training in the preparation, understanding and use of schedules in the construction industry. This is apparent not only in contractors but also owners, architects and engineers. The other issues listed above are more challenging to resolve.

There are solutions. The following suggestions and real life examples will hopefully give the doubters some encouragement for the continued successful use of schedules.

Training

Lack of training in planning and scheduling is a comparatively easy matter to deal with; there are many organisations that provide excellent scheduling training courses. Today many universities and technical colleges offer scheduling courses, and many excellent books have been written on the subject. In addition there are companies which provide customised in-house training in scheduling.

Construction companies require sufficient sales volume in order to justify employing a full time scheduler. Unfortunately, this is often an entry-level position for a recent graduate who may know how to manipulate software but knows little about construction. Planning and scheduling a complex construction project requires knowledge of the process that can only be gained through experience. In most small and medium sized firms, the project manager is often the scheduler. Having a project manager who has been properly trained to create schedules makes good fiscal sense; the benefits will ultimately far outweigh the cost of training. In fact the project manager should always be involved in the planning and scheduling of a project.

²"Construction Planning & Scheduling,"The Associated General Contractors (AGC) of America, June 1997, p. 3.

The "Partnered" Approach to Scheduling

Much has been written about the use of partnering on construction projects. In essence, a partnered project is one where all the project stakeholders — owner, contractor, architect, engineer and consultants — get together and agree, usually prior to the project actually breaking ground, to work **together** to successfully achieve the common goals of the project. In addition, a dispute resolution process or 'ladder' is established clearly setting out the method, roles and responsibilities of each party.

In a modified version of this approach, the basic principles of partnering can be applied to assist project teams in working together to plan and schedule quite complex projects.

Many readers will have been involved in a project where the project schedule is duly updated monthly by the contractor, in accordance with the contract, and submitted to the owner. Several weeks pass and a response comes back from the owner that essentially states "the schedule has slipped, the contractor must do whatever is necessary to make up the lost time and clearly all the change orders which were issued have not delayed the project by so much as a minute! And please note liquidated damages will be applied if you are late." The contractor immediately fires off a letter, justifying delays stating something like "for the record the project has indeed been delayed, it's not our fault, it's your fault and by the way we're going to file a delay claim and if we have to we'll sue!" Usually the next letter will start with "Without prejudice" in bold type, followed by dire warnings and sometimes threats about what will happen if the work is not done on time, and usually concludes with: "Govern yourself accordingly". This is sometimes referred to as the 'end of good will letter' on a project and things are now on the slippery slope that may ultimately end up heading for court or arbitration.

Contrast the foregoing scenario with one where the parties actually work together to sort out the scheduling issues. A case in point was a quite complex bridge rehabilitation project running behind schedule. (The delay was caused mainly by very poor weather during the summer construction season, but was compounded by an extreme shortage of skilled labour.) In addition to making up the lost time, the

owner was also anxious to accelerate the work to achieve an early completion. Rather than argue about who was responsible for the delays and their associated costs along with the cost of acceleration the contractor and owner held joint or 'partnered' schedule update meetings. There was no formal or binding contractual arrangement for these meetings; they were held simply on the basis that they would surely benefit the project. During these meetings, which took place on neutral ground, detailed discussions were conducted regarding the previous month's progress and the issues to be dealt with by the stakeholders. Having the computerised schedule projected on the wall during the process allowed the participants to examine the issues and study the matter, with good constructive dialog as the result. Both parties had time to present their concerns and to ask questions of the other. Delays were noted and agreement was usually reached on responsibility for the individual delays.

There is no guarantee that this technique will result in peace and harmony on the project. Since both parties were involved in producing and updating the schedule, even if the process disintegrates and a claim results, agreement on the facts contained within the schedule should be more easily reached than with a schedule produced and updated by only one party. Such an agreement can result in significant cost savings to both parties.

Even more significant was the great synergy that developed when project engineers and contractor put their heads together to come up with innovative and creative means to shorten the schedule. Because these meetings were 'partnered' the floor was open and all ideas could be discussed, in other words there was no such thing as a bad idea.

As the winter approached it became more and more vital to complete the bridge deck pours. The contractor met with the project engineers and by using the schedule demonstrated the impossibility of their current situation. However, the contractor had an idea that could save considerable time on the remaining deck pour. A "what-if" analysis was performed on the proposed method and it was found that indeed if the altered approach was employed, the bridge deck could be completed prior to the onset of winter. The proposed method required the engineer to

accept modifications to the concrete pouring sequences specified and would result in a significant reduction on the time required to complete the project. In view of these facts, the owner accepted the proposal and the project was executed on this basis.

It is unlikely that the contractor would have been able to convince the engineer to accept the modifications if the case had not been clearly demonstrated using the schedule. In addition, it was vital that the whole scheduling process be open and transparent and that the engineer, as well as the contractor, could see the project's status, and that there was no hidden agenda at work.

This approach requires goodwill and an honest attempt by all parties to progress the job, save cost and avoid litigation. It may not be easy to achieve, but it can and has been done very successfully.

Resource and Cost Loaded Schedules

The Critical Path of a schedule is usually defined as the sequence of activities that will take the longest time to complete, and is calculated by summing the duration of each activity falling on the critical path. In order to be useful, the duration of scheduled activities must be based on factual data and not be the result of guesswork or the use of horoscopes and crystal balls. For example, if we know that one crew can install ten widgets in a day, that there are one hundred widgets to be installed, and that only one widget installation crew is available, it will take ten days to install all the widgets. Therefore with that resource the task cannot be done in less than ten days.

It is important to note that very often the critical path is actually driven by the resources available to complete activities that lie on the critical path. In other words, the critical path flows through the resources. A simple illustration would be a high-rise apartment building with one tower crane. The project schedule may call for pre-cast concrete panels to be installed externally on the tower, at the same time that formwork is to be relocated on the adjacent underground parking structure, and the elevator rails are to be lifted into the elevator shaft. Clearly one tower crane cannot perform these three tasks simultaneously and a work around solution must be found. However, if at the outset of the project the schedule had the

tower crane defined as a resource and scheduled accordingly, the conflicting resource usage would have been detected and the work rescheduled. This is known as resource loading the schedule. The foregoing example is simplistic but serves to illustrate. The properly resource loaded schedule allocates all resources, including labour and equipment, for each activity on the schedule. Such a schedule allows the project manager to plan the most efficient and effective use of the resources available and to monitor productivity. Furthermore, the resource loaded schedule clearly records not only the planned sequence of events and the logical relationships between them, but also includes the resources on which the contractor based its plan.

To illustrate how this information may be useful, let us return to the widget example. Suppose the widget installation happens to end up on the schedule critical path and the project owner wishes to advance the completion date of the project by a week. An examination of the schedule resources will quickly reveal that by adding a second widget crew to the project the duration of the activity should be halved, thus saving five days on the schedule. In this case the owner can clearly see that investing in a second crew is not money wasted.

When a project falls behind schedule, contractors may be inclined to simply reduce the planned duration of an activity in order to show less delay on the schedule. This sort of delusional action serves no one well. There are only three ways to reduce the duration of an activity, namely: reduce the amount of work to be done, increase the resources being used to accomplish the task (such as adding a widget crew) or improve productivity. However, there are practical

limits to how many resources can be added to any single task or how and by how much productivity can be increased.

Money is a resource that should also be included in the schedule data. At its simplest level a cost loaded schedule will produce a cash flow curve which is a fundamental requirement of most contracts. At a higher level, cost and resource loaded schedules can be used to determine the earned value on a project.

Computerised Schedules vs. Squared Paper

At the beginning of this article the scheduling of the Empire State Building was briefly discussed. Built in the 1930s this project was obviously planned and scheduled without the aid of powerful computers and modern scheduling software; it was most likely scheduled using squared paper and a pencil. The success of the project is testament to the power of such a 'primitive' scheduling system. In fact there are many situations today where a piece of paper and pencil are better and faster than using a computer. For example a project manager may produce a so-called "fragnet" on site in order to plan a specific sequence of tasks to be performed in a short period of time. A 'squared paper' schedule may also be used on site to schedule the use of a material hoist or tower crane. The big advantage of a hand produced schedule in such cases is that a computer and printer are not required and the schedule can be put to use immediately and is easily adjusted. The usefulness of a hand-drawn schedule should not be underestimated. Straightforward or simple projects may be planned and scheduled quite adequately by using a simple bar chart drawn on a piece of squared paper, providing, of course,

that the information contained in the schedule is accurate.

At the outset of a project many contractors may actually prepare the master project schedule on paper, working out the overall approach to the project by hand. The hand-drawn paper schedule is then input to scheduling software and expanded to the necessary level of detail.

There can be no question, however, that computerised schedules have made the once daunting task of producing and updating large complex schedules much faster and easier. In addition, most scheduling software allows a project manager to examine alternate sequences of events by performing a 'what-if' analysis.

CONCLUSION

The time and effort spent preparing a proper initial project schedule, and performing subsequent regular monitoring is well spent and pays dividends on the final result of the project. As stated by the Business Roundtable "***Owners are the ultimate beneficiaries of improvements in cost, schedule, and quality of their construction projects***". Perhaps, as the 'ultimate beneficiaries', owners should give serious consideration to recognising the importance of schedules and adding an independent bid item for scheduling. Furthermore, since contractors will also benefit from properly prepared and updated schedules, consideration should be given to investing in schedule training and continuing education for key contractor employees.

Rest assured that, in construction at any rate, it is not a good idea to plan your project on the basis that "the sooner we get behind schedule the more time it gives us to get caught up"!

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