Time Impact Analysis — Measuring Project Delay

Introduction
Schedule delays are a frequent occurrence on many construction projects and can have immense cost consequences. Without the remedy of a time extension, mechanical contractors are often forced to work overtime and may be required to increase crews and supervision to mitigate delays, even when caused by others. Mechanical contractors may also be assessed liquidated damages for delay, along with possibly having to defend against delay claims from the prime contractor or other trades. In some instances, a mechanical contractor is not made aware of delaying events until it is too late to remedy the delay without incurring added costs that can be substantial.

The purpose of this bulletin is to alert mechanical contractors to several of the key elements of schedule usage and the development of time impact analyses to identify and quantify project delays. An important first step in this process is the mechanical contractor’s thorough review of the contract documents. The specifications generally contain the scheduling requirements for the project. Within this section of the specifications is often found the provisions governing timely notice and the requirements for a schedule impact analysis. Read the general conditions of your contract specifications carefully before any work is performed on the project. It is not unusual to find terms and conditions such as:

Contractor’s failure to submit its time impact analysis, with all supporting documentation and within the time period provided for in this contract, will constitute a full and final waiver of the contractor’s right to an extension of time arising from the alleged changed condition. Absent the timely and complete submission of the contractor’s time impact analysis as required by this contract, it is mutually agreed that the alleged changed condition has no effect on the critical path of the project schedule.

The method of delay impact analysis described in this bulletin is known as the “contemporaneous windows” method of analysis. The windows method measures delay at specific time windows throughout the project. The contemporaneous windows in time used for this type of analysis are usually the dates of the monthly update of the project schedule. While there are other methods of construction delay analysis, such as the “impacted as-planned,” the “as-built,” or the “collapsed as-built” methodologies, none offer the ability to evaluate the project at specific windows.
of time throughout the duration of the work. Moreover, some methodologies, including the “impacted as-planned” technique, have been generally discredited or strongly critiqued by courts and boards in reported cases. Many modern contract specifications require the “contemporaneous windows” method of delay impact analysis. This bulletin will describe this method of analysis using the terms employed by contract specifications that are encountered on many public and private construction projects.

Terms and Concepts Used in Delay Analysis

Activity—the basic unit of work in a construction schedule. The activity is the unit of work into which the overall project is divided for the purposes of tracking and managing time and labor during the construction process. The overall project is divided into activities during the job planning phase. Each activity is defined by specific geographic or contract boundaries such as phase, building, floor, and sectors; and by other designations, such as column lines, systems, rooms, crew codes, or other definitions that will allow specific identification of the work on the contract drawings. Each activity is given an estimated duration and is linked to other activities in the schedule by the use of logic restraints. Logic restraints (i.e., finish to start, start to start, finish to finish, and start to finish) define the relationship between activities in a construction schedule and are input by the scheduler to develop the overall Schedule Network.

Change Orders Critical Path Method (CPM) Scheduling—a formalized, and usually computerized, method of construction scheduling. This dynamic construction management tool requires the development of activities and interconnecting logic restraints. The activities are analyzed to determine how each interrelates to other activities on the overall project with regard to performance dates. Logic restraints are created between the activities to create the CPM schedule network, which is the graphic representation of the overall schedule showing the activities and the interconnecting logic restraints. The CPM schedule should demonstrate the most efficient and profitable means of completing the project within the performance time set forth in the contract.

Critical Path—the longest connected chain (or chains, in the case of multiple critical paths) of activities in a CPM schedule that, if delayed, will have an equivalent impact on the end date of the project.

Total Float—the number of days an activity can be delayed from its earliest start date, or its earliest finish date, without causing delay to the completion of the project. Activities on the critical path have zero (0) total float. Total float is a computation that is derived from the CPM schedule network and is dependent on the duration of the activities and the logic restraints that are input by the scheduler. Total float can change with each progress update or modification made to the original schedule.

Most contract specifications contain a “shared total float” clause. Such clauses state that total float is a commodity to be shared between the parties to the contract. In the case of a delaying event, a time extension will be granted only to the extent that the delay first consumes the entire available total float and, thereafter, causes a delay to the critical path. Impact events, which only consume positive float when analyzed in the CPM schedule, will usually not result in the granting of a time extension.
Time Impact Analysis (TIA)—a series of activities and logic restraints that define what is known about a changed condition, such as work added by a scope change or work occasioned by a differing site condition. As the conditions change, or as more information is known about the potential delay, the TIA must be modified (evolved). The TIA has become a term of art in the industry and is referenced in many contract specifications regarding project scheduling, notice, and delay analysis. TIAs are input into the CPM schedule as soon as the changed condition is recognized and are inserted into the CPM schedule update with a status, or “data date,” closest in time to the date of the initiation or discovery of the potential impact event.

Fragnet—another term of art in the construction industry having the same definition as the TIA. The fragnet is a fragmentary portion of an overall project CPM schedule network that depicts the activities and logic associated with a potential schedule impact. The gapless evolving fragnet is a term of art that describes a process of identifying, defining, and developing over time, the discrete activities that form a potential impact to the project schedule. Maintaining contemporaneous documentation supporting the details of each delay activity is important in developing and supporting the TIA, or gapless evolving fragnet. The terms “TIA” and “fragnet” will be used interchangeably herein.

The Project Schedule

While this bulletin does not cover the means and methods of CPM schedule development, updating, and maintenance, some commentary concerning the scheduling process is useful. If the mechanical contractor is also the prime contractor on the project, the development and control of the schedule should not pose a problem. The prime mechanical contractor is usually tasked with the same type of overall scheduling responsibilities as would a typical general trades contractor or construction manager. In such cases, the prime mechanical contractor will be fully aware of the requirements of the project schedule and will know when TIAs are required to be developed and input into the overall project schedule.

The majority of mechanical contractors, however, are in the role of subcontractor to a prime contractor or construction manager. In such cases, the mechanical subcontractor may not have unfettered access to the prime contractor’s schedule. When that is the case, the mechanical subcontractor must take some affirmative steps regarding participation in the scheduling process. It is recommended that the following minimum steps be followed on every project:

- Request the opportunity to participate in the development of the project schedule.

It is essential that the mechanical subcontractor request that it be given a full and complete opportunity to participate in the development of the overall project schedule prepared by the prime contractor or construction manager. Furthermore, the mechanical subcontractor may, from time to time, be asked by the prime contractor to review, or to provide input into, the overall project schedule. The mechanical contractor should respond competently, comprehensively, and in a timely fashion to such requests.

- Request electronic copies of the project schedule and all updates.

It is often difficult, if not impossible, to conduct a meaningful schedule review using only a paper copy of the project.
schedule or updates thereto. Thus, the mechanical subcontractor should request in writing a magnetic media copy of the prime contractor’s baseline schedule and each progress update thereto. The mechanical subcontractor is then able to perform a much more detailed and thorough review of the prime contractor’s schedule. On public projects, when requests for the electronic scheduling files are denied by the owner, construction manager, or prime contractor, such files can sometimes be obtained through a Freedom of Information Act (FOIA) or “public information act” request filed by counsel.

- **Timely submit any TIAs in accordance with the contract documents.**

With or without the prime contractor’s assistance and cooperation, the mechanical subcontractor must submit its TIAs in accordance with the requirements of the specifications. The fact that a prime contractor may not utilize the TIA, or properly insert the TIA into the overall project schedule, does not relieve the mechanical subcontractor from fulfilling, to the fullest extent possible, its contractual obligations, if so specified, to develop and submit TIAs for events affecting the work of the mechanical contractor.

- **Utilize crew and equipment restraints to avoid “False Float” and possible stacking of trades or crew size inefficiencies.**

False float is an important concept to grasp for the mechanical contractor because the presence of false float may result in understated time impact analysis. Many contractors do not take into consideration the limitations of available crews or equipment items, such as cranes, and fail to insert crew and equipment restraints into the logic of the CPM schedule. The absence of these vital logic restraints can create false float which, in the event of a delay, may improperly consume the impacts when a TIA is inserted into the project schedule. When mechanical crew and equipment restraints are missing, a delay impact may show no delay computation in the project schedule due to false float. In fact, because of the lack of crew and equipment restraints, the mechanical subcontractor’s activities may become improperly “stacked” in the schedule in a manner that was totally unanticipated, in turn, leading to unplanned increases in crew or equipment requirements and their associated inefficiency and financial impact to the mechanical subcontractor.

### Contractual Obligations to Submit the TIA

Most current contract specifications contain requirements that the contractors submit a TIA, or fragnet analysis, in order to demonstrate the impact of changes or delays to the project schedule. Since most prime contractors include “flow down” provisions in their subcontracts with mechanical subcontractors, the mechanical subcontractor bears the same, or even a greater,7 burden as does the prime contractor in order to demonstrate the impact of changes, delays, and other disruptions to its work. An illustrative example of the clauses that typically appear in many contract specifications is the following:

**Contractor shall submit its time impact analysis within seven (7) calendar days after the initiation of the event that causes the alleged delay. The seven calendar day period shall begin at the point in time when the delaying event was known, or should have been known, to the contractor. The contractor shall**
submit its time impact analysis in the form of a CPM schedule fragnet analysis that will be inserted into the approved schedule update closest to the initiation of the delaying event. Failure of the contractor to submit its time impact analysis within the time limits set forth herein will result in a waiver by the contractor of any entitlement to an extension of time to the contract. By failing to submit its time impact analysis in the format and within the time requirements described herein, the contractor agrees that no time extension is required by the alleged change in scope or event and forevermore waives its rights to claim for such delay or impact of any sort or type.

- Notice requirements for TIAs should be strictly followed.

The time element imposed by the contract is dependent upon the specific project—some specifications allow as little as three (3) calendar days, some as much as thirty (30) calendar days or more. Notwithstanding the relatively short period allowed by many specifications to provide written notice and a TIA, such clauses may be enforceable under the controlling laws and, thus, cannot be taken lightly by the mechanical subcontractor. To vault the dual hurdles of delay identification and timely notice is a formidable task for the mechanical contractor. It is foolhardy to rely upon assurances from the prime contractor or construction manager’s employees that such requirements will not be enforced or that issues of delay and associated costs will “be dealt with” at the end of the job. In order to accommodate the rigid requirements of many current specifications, the mechanical subcontractor must strictly adhere to the CPM scheduling techniques described in the contract specifications.

- Contract conditions, payment applications, and change orders should be reviewed by the contractor and/or its legal counsel to avoid waiving valuable rights.

With more and more contract specifications being written with strict waiver clauses regarding notice and TIAs, it is a wise and prudent investment for the mechanical contractor and/or its construction counsel to review carefully the contract general conditions, payment application forms, and change order forms.8 Such a review at the outset of the project is critical to alerting the project management team as to its responsibilities and obligations regarding these crucial issues.

Development of the TIA

As described herein, many contract documents (usually a section in the scheduling specifications within the general conditions) require that fragnets, or TIAs, be inserted into the project schedule as delay events are known. These TIAs are to be placed into the update of the schedule closest in time to the notice to proceed of the changed condition, or in the update closest to the start of the impact of the changed condition. Since most TIAs are prepared and submitted before all of the potentially delaying events are known, the TIA must be evolved from update to update. The steps to prepare an evolving TIA are generally as follows:

- Draw out the TIA logic, in detail, to include all discrete activities that are known at the time the potential impact is identified, or can be reasonably predicted as a result of the impact event.

Such information may include the issuance of an RFI, the waiting period for a response, the analysis and pricing of the response and a forecast of
change order processing time, procurement of any materials and equipment required by the impact event, and the actual work to address the event. Each of these items should be designated as a separate activity in the TIA.

- Ensure that there are no unidentified gaps in time within the fragnet.

From the start date of the fragnet event until it finishes, or is forecast to finish, every significant period in time must be identified as an activity within the TIA. For instance, if the contractor must wait for five (5) weeks for the owner’s response to an RFI, then the five (5) week period would be identified as an activity, such as “Contractor Waiting for Owner’s Response to RFI No. 50.” The TIA must be gapless—every day must be accounted for by an activity describing the events of each time period, whether “waiting” for a response, “negotiating” the change documents, or actually performing the changed work scope.

- The existing base contract activity(ies) that are, or may be, affected by the TIA must be identified. The TIA is then logically tied to the affected activity(ies) in the CPM schedule to determine what, if any, impact has been caused by the event.

The mathematical analysis of the schedule update can be rerun and the scheduler can determine if the fragnet has changed the critical path by comparing the pre-impacted schedule with the impacted version.

- Each succeeding month after the first update into which the TIA has been inserted, the TIA can be “evolved” with information as it becomes available regarding the scope and timing of the TIA Activities.

Although the step of forecasting activities in the evolving TIA (also known as the gapless evolving fragnet) may be somewhat subjective, it is essential in meeting many of the specification requirements now being included in contracts. Contemporaneously, maintaining notations or other records that support these forecasts of future events that are depicted in the TIA can provide an important historical record. In addition, including the latest information regarding the TIA in the most current schedule update allows the mechanical contractor to manage the work to mitigate the impact of the delay.

- As the contractor looks forward in the CPM schedule to the point at which the potential delay event will affect the base contract work, it is important to tie the ending activity of the TIA into the earliest base contract activity which could be affected by the TIA logic.

This tie point from the TIA into the base
contract schedule is extremely important and should be established with care. With regard to new scopes of work arising from the TIA that must be defined as activities, it is essential that these new activities be sequenced within the existing logic of the schedule so as to maintain the contractor's planned crew restraints.

- **With each update, the scheduler can note the effects of the various TIAS on the overall Critical Path of the project schedule.**

The Critical Path impacts, if any, will evolve along with the input and updating of the TIA data. In fact, the impact of the TIA on the Critical Path may change from month to month as other job conditions also change.

- **If the impacts of the TIA are expected to include labor inefficiencies, these estimated inefficiencies can be forward priced using “Factors Affecting Labor Productivity” and “How to Use the MCAA Labor Factors.”**

To the extent that the mechanical contractor must, or desires to, include all of the potential impacts in a forward looking TIA, the contractor must consider if the TIA will impact the productivity of the base contract work. If the contractor will be required to bring in new workers that may be unfamiliar with the project, work overtime, or work in an unanticipated manner concurrently with other trades, the scope change work and the base contract work could be adversely affected in terms of labor productivity. In such cases, the mechanical contractor should reference the bulletins on “Factors Affecting Labor Productivity” and “How to Use the MCAA Labor Factors” to estimate the potential loss of labor productivity to the scope change work and possibly to the base contract work as well. This loss of productivity will be manifested in either added labor to overcome the effects of the inefficiencies, overtime, or longer activity durations that can result from inefficiency.

For example, if a base contract activity of 18 planned work days for the installation of piping branches is expected to sustain a loss of productivity of 20 percent caused by “stacking of trades” because it will be performed in a different working environment resulting from the time slippage demonstrated by a TIA, the duration of the activity can be increased to 22 work days (18 x 1.2). By including this consideration, where possible, in the overall TIA, the mechanical contractor may be more fully compensated for impacts arising from changes in scope. “How to Use the MCAA Labor Factors” explains how the estimated durations of schedule activities can be impacted using the inefficiency factors contained in “Factors Affecting Labor Productivity.”

- **If a change order is executed regarding an evolving TIA (i.e., is executed before the delay impacts are actualized), the contractor should reserve its rights as to any future impacts of the evolving delay events.**

Assuming that the delay event is recognized as a change in scope to the mechanical contractor’s contract, a formal change order may be executed. The change order form may contain “full accord and satisfaction” language that is designed to bar the contractor from receiving any further compensation (time and/or money) arising from the change. If the mechanical contractor is required, or decides, to execute such change order forms before the full effect of the TIA is known, it is essential that the estimates for future impacts of the
Labor Inefficiency Arising from Changed Conditions Can Adversely Affect the Project CPM Schedule (Exhibit A)

TIA to the schedule be very carefully assessed. Once the mechanical contractor executes a “full and final” change order, it may be difficult or impossible for the contractor to later make a claim for added costs arising from the change, such as longer than anticipated procurement times or for inefficiencies arising from a disruption to the crews performing the work. The aforementioned steps that describe the TIA process are graphically depicted in this bulletin and they are as follows:

- **Step 1:** The process starts with a properly developed CPM schedule (one which includes a reasonable level of detail, mechanical crew, and equipment restraints). A faulty CPM schedule will serve little purpose in managing the project or in analyzing the effects of changes as they occur. The graphic in step 1 shows a portion of the base contract work in a mechanical equipment room depicted in a CPM schedule format.

- **Step 2:** In this example, assume that the mechanical contractor discovers a differing condition or design deficiency. By way of example, assume that structural elements of the building conflict with the physical location of major mechanical equipment in a mechanical room. The mechanical contractor prepares
and submits an RFI upon discovering this condition and must await the owner’s response. Note that, in the example shown in Step 2, the contractor has prepared a TIA starting with an activity that describes the submittal of the RFI, the period awaiting a response, and the date on which the response was received; all of which are historical dates in this example. However, from this point forward, the contractor may not know the scope of the change nor does the contractor have authority to proceed with a modified scope of work. Therefore, in this TIA example, the contractor has estimated a period of 20 work days for the owner to define the scope of the changed condition and agree upon a cost for the added work. Having complete and detailed information concerning all of the elements of a TIA is not a condition precedent to the development of an evolving TIA.

- **Step 3:** Within the next update period, the TIA is evolved by the mechanical contractor. By schedule update No. 2, as shown on the graphic, the mechanical contractor and owner have defined the modified scope of work and the contractor has received a notice to proceed to perform the scope change. The new activities are added to the TIA and now sufficient information is available for the mechanical contractor to understand what work must be accomplished in the field to carry out the scope change. As such, the contractor has added the forecast for the required equipment relocation for 10 days and has identified 10 days of work that must be added to the base contract work for the relocation of CHWS/R branch piping.

- **Step 4:** The TIA has been evolved to the extent that the mechanical contractor can tie the TIA logic into the base contract activity(ies) in the master CPM schedule. In Step 4, the TIA activity for equipment relocation for 10 days will be performed by a separate rigging crew and thus can begin as soon as the change order is approved. However, the additional 10 days of work associated with relocation of the branch piping will be performed by the mechanical contractor’s existing piping crew. Therefore, the TIA activity that describes the added work for CHWS/R branch piping must be inserted within the existing crew flow for the piping work.

In this manner, the schedule will maintain the planned flow of the crews and will not depict added crews that the contractor did not anticipate. The failure to integrate TIA activities into the existing logic with regard to crew flow may result in false float and no impact, or incorrectly attenuated impact, to the CPM schedule.

By inserting the TIA activity that is to be performed by the base contract crew (in this graphic example, the added work for relocation of the CHWS/R branch piping) within the existing crew flow, the dependent activity of CHWS/R piping drops to the chillers and pumps is impacted by 10 work days. To the extent that this base contract work was on the critical path of the CPM schedule, the mechanical contractor would be entitled to a time extension of 10 work days,
or 14 calendar days. This time extension could be both excusable and compensable.

**Conclusion**

While it would be desirable for all of the impact events to become historical (actualized) before a change order is initiated to cover the effects (costs and time) of a delay impact, the current specifications in wide use today attempt to provide a means for scope changes to be fully executed early in the life of a time impact so that all of the time and cost impacts are included in the change order. This goal, if achieved, can reduce the incidence of “after-the-fact” claims that are submitted at the conclusion of the project. If properly and cooperatively implemented, “real time” TIA analyses that lead to the settlement of delay events, such as changes in scope, can mutually benefit the contracting community and owners. Unfortunately, the contemporaneous settlement of “real time” TIA is the exception, not the rule, in the construction industry.

In order for this potential benefit of “real time” impact settlements to be realized however, the subcontractors, prime contractor, and construction managers/owners must make the CPM schedule a mutually shared commodity. If the prime contractor holds the scheduling information under lock and key and does not encourage, or allow, the mechanical contractor to participate in the development of the baseline schedule and in the maintenance and updating of the schedule as the project moves forward, the goal of obtaining “real time” impact settlements will remain elusive.

In most instances, the terms and conditions of the contract will dictate what the mechanical contractor must do with regard to development and submission of TIA. Unfortunately, in some cases this means that the mechanical contractor may have to prepare its TIA without the assistance or cooperation of the prime contractor. That notwithstanding, in today’s litigious environment, the mechanical contractor cannot afford to ignore any of the requirements contained within the general conditions of the contract and must take every reasonable step to preserve its right to be fairly compensated for impacts and delays.

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1 A “unit of work” includes all elements of field installation as well as submittal preparation, engineer’s submittal review, and prefabrication.

2 It is possible for the most critical path to have positive float, a concept which is not discussed herein.

3 TIA are generally created at the outset of a potential delay and, as such, will not contain a complete delay analysis because the entire scope of the TIA will not be apparent. Therefore, the TIA must be evolved from month to month to show the development of the potential delay. This evolution requires the addition of new activities to the TIA, such as responses to RFIs, approval of a change order, direction to proceed, and definition of the actual work involved in the change.

4 All scheduling software systems, such as Primavera®, allow the electronic schedule files to be written onto transferable media such as compact discs. The electronic scheduling files can also be easily transmitted by e-mail.

5 “False Float” is relative float (relative to the float on the controlling critical path) that is improperly shown in a CPM schedule, usually arising from the absence of proper crew and equipment restraints. In many cases, False Float incorrectly absorbs the time impacts of fragnets inserted into the schedule, resulting in no measurable delaying effect on the project end date. False float can deprive a contractor of its entitlement to an otherwise excusable delay event.
A “flow down” provision contains language that places the same requirements and obligations on the subcontractor as the prime contractor has with the owner or construction manager.

In many subcontracts, the mechanical subcontractor is required to provide its notice of delay, or TIA, in such a manner that the prime contractor can meet its timing obligations for notice and quantification with the owner in its contract. Essentially, this requirement means that the mechanical contractor must submit its TIA or notice in less time than the prime contractor is provided in its contract with the owner or construction manager to submit its TIA or notice.

The regular monthly payment application form provided to the mechanical contractor by the prime contractor, construction manager, or owner may contain waiver language that must be addressed with each and every monthly payment application in order to preserve the contractor’s rights for compensation for such things as unsettled change orders and impact events that are known, but not covered, by a formal change in scope. Some prime contractors’ monthly payment application forms contain full or partial release language that attempts to bar the subcontractor’s recovery of unexecuted changes in scope or delay and impact claims. Similarly, the change order form used on the project may contain “full accord and satisfaction” language that may severely limit or restrict the contractor’s rights to seek additional relief beyond what is explicitly set forth in the change order.

The concept of impacts of multiple changes to the base contract work is known as a “cumulative impact claim” and care must be taken to price comprehensively the effects of changes to the base contract hours. The contractor should provide exculpatory language on the change proposal in the event that comprehensive pricing is not possible. It is recommended that “How to Use the MCAA Labor Factors” be consulted for a more detailed explanation of this condition.

If the mechanical contractor is required to execute “full accord and satisfaction” change orders before delay impacts are actualized by, among other things, the threat of non-payment for the change work, it is prudent for the contractor to consult with legal counsel as to options that may limit or qualify the “full accord” language.

If the mechanical contractor has reason to believe that the prime contractor’s CPM schedule is defective, written notice of this determination should be transmitted to the prime contractor with regard to the baseline (original as-planned schedule) and each successive update thereto.

This operation assumes that the mechanical contractor plans to execute the scope change work with the crews already on site. In the event that the contractor mobilizes new or separate crews to perform scope change work, it may not be necessary to consider the disruption of the TIA Activities to the existing crew flow.

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Four Step Fragnet Example (Exhibit B)