Principles

of

SCHEDULE IMPACT ANALYSIS

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1 INTRODUCTION

From a scheduling standpoint, the goal of every project is to be delivered on time and within budget, with desired functionality and acceptable quality level. In an ideal world, projects follow early starts and early finishes, float is not consumed, deadlines are met, the contractor never files claims for time extension, and the owner never assesses liquidated damages. Such a scenario rarely exists on construction projects – events occur that potentially affect the planned completion of work, requiring a need to evaluate the impending impact of this event on the project schedule.

Schedule impact analysis is defined as the process of quantifying and apportioning the effect of delay or change on a project schedule. Although not all events that differ from the planned schedule of work will result in a schedule impact, this document is written to identify events that *will* have an impact, show what that impact is, and assign responsibility for the impact. Figure 1 summarizes the key elements of a schedule impact, in bar chart format. The *As-Planned (Baseline)* schedule includes the entire planned duration of the project, while the *As-Built to Date* represents the duration of work that has been completed to the present time. At this "present time", it is realized that the project may not finish on time, and the owner wants to know when the project will be delivered. Events have taken place, which are determined to impact the remaining schedule, as shown by the *To Build* bar. As stated before, a schedule impact analysis is the process of quantifying and apportioning the effect of this delay. The *Total Impact* quantifies the effect that these events have had on the projected completion date of the project, and it is now time to apportion responsibility for why the project will be delivered late.

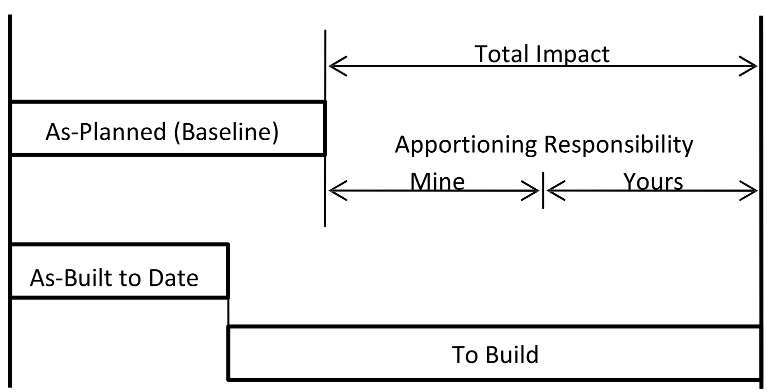


Figure 1: Overview of Schedule Impact Analysis

Without implementation of a proper schedule impact technique, it is difficult, if not impossible, to accurately quantify and apportion the impact that a delay or change has on the completion of a project. Too often are time extensions and damages assessed based on simplistic measures, such as robotically using the total duration of a delay for granting the number of days for a time extension, rather than considering all influences on the project and its schedule and addressing the delay using a method that utilizes a critical path analysis. CPM scheduling forms the backbone of both this document and of effective schedule impact analysis techniques. The critical path method's ability to accurately represent living, growing projects are what makes it ideal for determining how an event may potentially impact project completion.

This report emphasizes how to identify and classify potential schedule impacts, as well as how to determine what, if any effect they have on the project completion date. In Chapter 3, discussion of the key elements of baseline schedules, updated and revised schedules of record, and as-built schedules show the reader the importance of properly maintaining these documents in a manner that will be most beneficial when claims are filed for time extensions or damages. Maintaining schedule documents are essential to any successful claim or defense against claim, as courts have upheld that regularly updated and maintained schedules most accurately portray the project in its completion. Chapter 4 discusses the different types and causes of schedule impacts. Whether caused by the owner, contractor, or another source out of their control, there are different types of events that may impact the schedule. After events are identified, they are then classified into categories of excusable/non-excusable and compensable/non-compensable delays. Doing so prepares the delays for a schedule impact analysis. Eight different schedule impact analysis techniques are reviewed in Chapter 5, which use a common, basic example to show how each method is implemented. Techniques vary in their use of CPM schedules, utilizing as-planned and as-built schedules in both retrospective and contemporaneous manners. A comparison of methods will give insight into the results of the analysis, followed by recommendations of the most accurate schedule impact techniques, discussed in Chapter 6, which show clear advantages to using certain techniques instead of others.

The intended audience for this report is executives and managers who want an overview of the principles of schedule impact analysis and how they are applied, in order to have a better understanding of information presented by schedule analysts. This document is not intended to prepare the reader to perform a schedule impact analysis of an actual project, but to educate on the fundamentals of schedule impacts and their use in accurately determining the potential effect a delay or change has on the schedule and on timely project completion.

2 TERMINOLOGY

This chapter will define key terms that are used throughout the report. It is assumed that the reader has knowledge of the principles of planning and scheduling. If this is not the case, a precursor to this report is the technical report "An Introduction to the Management Principles of Scheduling" by Brian Munoz, VDOT-VT Partnership for Project Scheduling. The following definitions are identified by the VDOT-VT Partnership for Project Scheduling, with reference to the following sources: Bartholomew 2002, Bramble et al. 1990, and Parvin 1993.

Act of God – a natural occurrence caused directly and exclusively by natural forces without any human intervention, which could not have been reasonably foreseen or prevented by the contractor or any other party to the contract

Adjusted As-Built – a retrospective schedule impact analysis technique that uses a one time, after-the-fact insertion of owner and excusable delays into the as-built schedule to quantify global impact

Adjusted As-Planned – a retrospective schedule impact analysis technique in which delays are incorporated into the original CPM without regard to actual progress or historical work activity data, in order to quantify global impact

As-Built Schedule – an accurate historical representation of the actual sequence of construction and how it was completed

Baseline (As-Planned) Schedule – the target construction schedule based on the contractor's original understanding of the project and used as the standard by which progress is measured

Cardinal Change – a change (either directed or constructive) to the contract that, because of size or the nature of the changed work, is clearly beyond the general scope of the contract

Change – when a contractor takes on any type of work that deviates from the original contract, or from the scope of work or plan of action reasonably anticipated under the contract

Collapsed As-Built (But-for) – a retrospective schedule impact analysis technique that apportions responsibility for each party by removing all sources of each delay (owner, excusable, contractor) to quantify global impact

Concurrent Delays – independent sources of delay that occur at same time and/or on separate parallel paths of a CPM network

Constructive Change – a change that is not acknowledged by the owner as such when it occurs, but which nonetheless is a change

Contemporaneous Technique – a schedule impact analysis technique applied at the time of the potential schedule impact

Contractor Responsible Delay (CRD) – a delay attributable to the contractor's actions or inactions

Convenience Termination – contract clause permitting the owner to terminate the contract at the convenience of the owner, based on specific needs of the owner

Default Termination – contract clause permitting the owner to terminate the contract when the contractor is not meeting the contract requirements

Delay – the lack of performance or the extension of time required to complete a project that results from unexpected events; may be caused by the contractor, the owner, third parties, or by unanticipated natural or artificial site conditions

Differing Site Condition – a material, significant difference between the conditions represented in the contract and those encountered on site

Directed Change – a directed written modification to the contract that orders the contractor to make specific changes to the work required by the project plans and specifications

Disruption – the lost productivity that results from interruptions in the planned sequence of operations

Excusable Delay (ED) – as used in the schedule impact analysis techniques, a delay not attributable to either the contractor or owner

Excusable, Compensable Delay – a delay that will serve to justify an extension of contract performance time, as well as award delay damages; a delay at fault of the owner

Excusable, Non-Compensable Delay – a delay not attributable to the contractor or owner, which will serve to justify an extension of contract performance time, but no monetary compensation

Force Majeure – unforeseen events with causes beyond the contractor's control, for which the contractor is deemed excusable in their failure to perform within the required time limits

Global Impact – a retrospective schedule impact analysis technique that plots all delays on an as-built bar chart, equating the total delay to be the sum total of the durations of all delaying events

Impacted Updated (Veterans Administration) – a schedule impact analysis technique that can be applied in a retrospective *or* contemporaneous manner, inserting delays into an updated as-planned schedule to quantify impact; separate calculations for each alleged delay-causing event are not required

Modification Impact Analysis (U.S. Army Corps of Engineers) – a contemporaneous schedule impact analysis technique in which at the time of modification, the actual status of the job is determined, the schedule is updated, and the delay is inserted to quantify singular impact

Net Impact – a retrospective schedule impact analysis technique that attempts to justify time extension by showing all delaying events on an as-built bar chart, claiming total project delay is the claim for time extension

Non-Excusable, Compensable Delay – a peculiar situation in which an owner and contractor are concurrently delaying the project, and monetary compensation for the owner's delay can be properly apportioned

Non-Excusable, Non-Compensable Delay – a delay caused by the contractor's actions and/or inactions that denies the contractor claims for either time extensions or compensation; the contractor may also be held liable for liquidated damages

Owner Responsible Delay (ORD) – a delay attributable to the owner's actions or inactions

Retrospective Technique – a backward-looking schedule impact analysis technique that is applied upon project completion

Schedule Impact – the potential effect of a delay or change on a project schedule; may be in the form of delay or change in project completion date, delay or change in project sequence, or consumption of float

Schedule Impact Analysis (SIA) – the process of quantifying and apportioning the effect of delay or change on the project schedule

Schedule of Record (SOR) – the current accepted construction schedule, recently updated or revised, to reflect actual progression of the work and resulting changes to the work plan

Suspension – a written directive by the owner to stop all work on the project, either because the contractor has failed to perform in accordance with contract documents, or at the owner's convenience

Time Impact Analysis – similar to the Modification Impact Analysis, a schedule impact analysis technique that recreates the actual status of the job at the time of modification, updates the schedule, inserts delays, and quantifies singular impact; although retrospective in that it is done after the fact, it has a contemporaneous orientation, not a hindsight perspective

Type I Differing Site Condition – a contract misrepresentation; a physical condition encountered on the site that differs materially from that represented in the contract documents

Type II Differing Site Condition – an unknown physical condition encountered that is not represented in the contract, and is not normally expected in the type of construction work performed

3 SCHEDULES

3.1 Baseline Schedule

The as-planned schedule, or the *baseline schedule*, outlines a contractor's original understanding and plan of action for a project. To provide a complete overview of the project scope, the "baseline" should include all aspects of the project, including all subcontracted work. Detail must be enough to measure progress and quantify impacts, but operations are often generalized at a summary level. Placing too much emphasis on minute detail in this stage of scheduling may result in large concepts being missed [Clough et al. 2000]. The owner has four uses for the baseline schedule:

1. Ensure the plan meets the contractual requirements
2. Datum for measuring progress
3. Framework for quantifying impacts
4. Schedule their portion of the work [Hildreth 2005]

The baseline is more than a single document, but rather it is comprised of the following components:

- Schedule Chart – a time-scaled bar chart showing early start, early finish, duration, float, and activity links
- Progress curves – curves depicting progress in terms of money, resources, and commodities
- Tabular report – summary of events and scheduled milestone dates
- Baseline narrative (project or schedule narrative)
  - Guidebook for the baseline schedule
  - Concise overview and background information
  - Aimed at improving understanding and communication [Hildreth 2005] The

baseline will serve as a benchmark for which all future updated schedules will be compared. For this reason, both the contractor and owner need to be in agreement of the baseline schedule. It is essential for the owner to approve the baseline in an early stage, because once changes take place, impartiality towards these changes in the schedule may become difficult [Clough et al. 2000].

3.2 Establishing the Schedule of Record

The baseline schedule serves as the basis for the evaluation of future progress reporting and project changes [Clough et al. 2000]. Once established and approved, the baseline is set in stone, and become the *schedule of record (SOR)*. Progress and project changes can be made to the baseline; once an update or change has been made and this new schedule is agreed upon and approved, it is referred to as the most current schedule of record. An updated schedule of record reflects the dynamics of a living, changing project [Clough et al. 2000].

The following flowchart (Figure 2) shows the steps involved in updating or revising the current SOR. If this is the first update or change, the baseline schedule is the current SOR. The chart is split vertically into two halves; which path taken depends on whether the owner and contractor agree that there has been a change. Regardless if there has been a change, keep track of project progress by updating the SOR on a monthly basis. These periodic updates will keep will reflect the status of work completed to date and provide and opportunity to replan the remainder of the project based on the current status and experience gained thus far [Clough et al. 2000].

The flowchart can reach one of three conclusions:

1. An update of the SOR to reflect current project status, maintaining the current SOR
2. A revision to the SOR to reflect the revised work plan, developing a new SOR
3. The contractor not agreeing to the work order, in which procedures for submission of a claim are outlined in Section 105.16 of the Roads and Bridges Specs

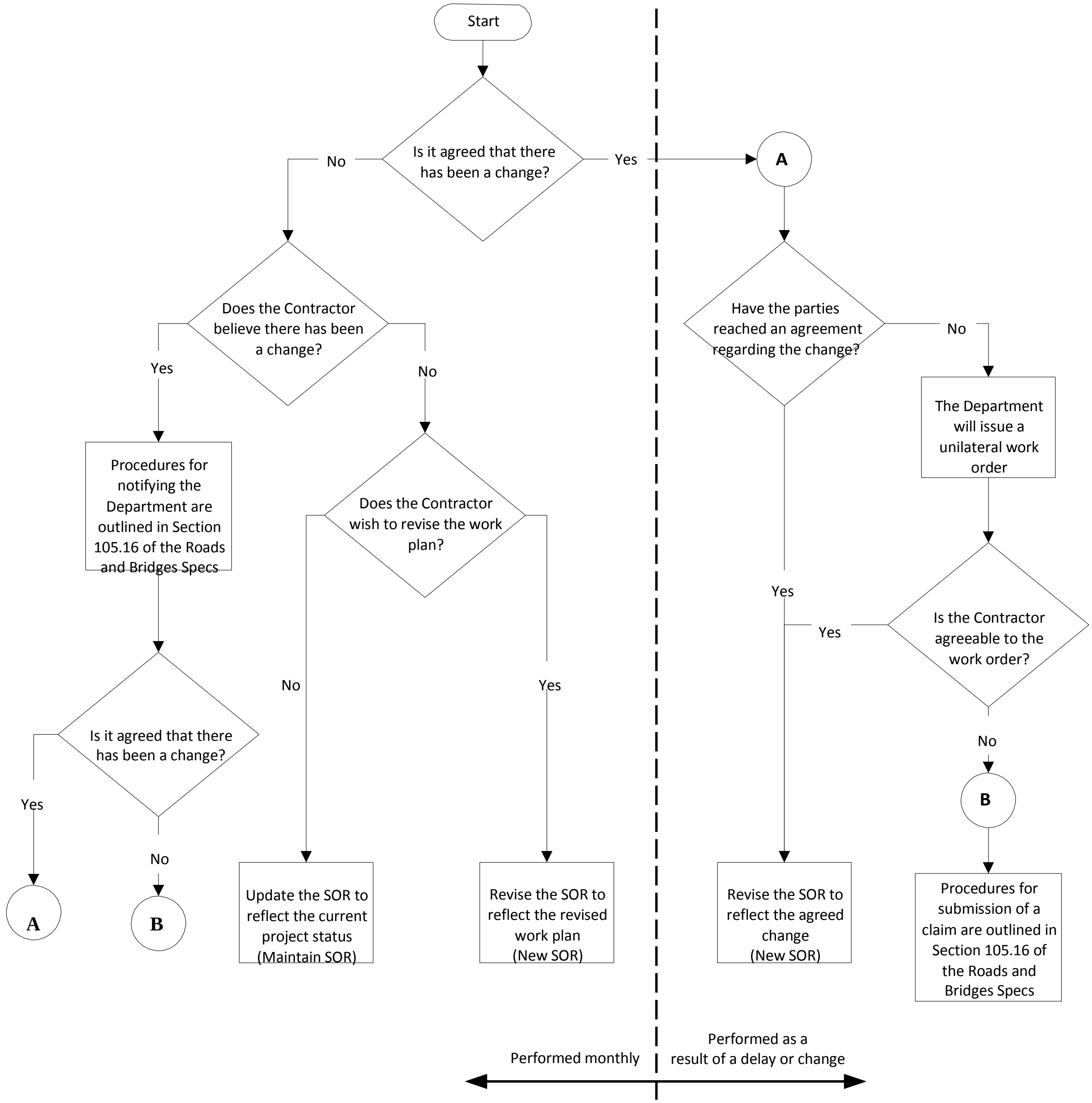


Figure 2: Schedule of Record Flowchart

Whether scheduled updates are made every two weeks or on a monthly basis, preparing for an update involves gathering, reviewing, validating, and incorporating all information needed for a schedule update meeting. Each party compiles this data to review and assess the schedule to identify all activities scheduled to start or to be completed during the report period. The next task is to determine the following, as provided by Wickwire et al. 2003:

For an *update* of the SOR:

1. *Start and finish dates for all activities started and/or finished during the report period.* It is suggested that all such dates be supported by factual performance documents contained in the project record-keeping systems.

2. *The current status of all activities reported as being in progress in the last update report.* If they were completed during the current report period, the date of actual completion should be recorded. For those activities that remain in progress (including those started during the current update period), the time remaining should be estimated and recorded.

For a *revision* of the SOR, in addition to 1 and 2 above:

3. *Activities that need to be resequenced, added, deleted, or modified* to add clarification, to reflect a change in plan of operation, or to maintain required schedule detail for proper monitoring and control.

4. *The fragnets that have to be incorporated into the schedule* to reflect delays and/or change conditions that influence the schedule, progress, and forecast of the project.

In addition to these tasks, if recognized that the project is legitimately behind schedule, incorporate a plan of recovery where deemed appropriate [Wickwire et al. 2003]. Recovery plans may change activity lengths and logic, and are to be considered.

The process of updating and revising the schedule of record are not to be pushed aside. Approving the baseline schedule and schedules of record is useless if the contractor does not maintain the current schedule of record as agreed by the parties. To prevent this situation, owners are encouraged to include scheduling specification to assure that all parties working to and evaluating the project from the same schedule [Wickwire et al. 2003].

3.3 Developing an As-Built Schedule

As new schedules of record are updated and modified, they are forming the basis of what will be referred to as the *as-built* schedule – a final documentation of actual starts and finishes of activities, any delays, change orders, extra work, weather, and other factors that affected project completion. As-built activities should correspond to those of the baseline schedule, although it may be necessary to account for changes in activities and logic. The as-built is an accurate historical representation of the actual sequence of construction and how it was completed. Project timing, sequence, and logic are developed through daily recording of various information, coming from an array of sources (Figure 3). Further, developing a list of problems, disputes, changes, and delay-causing events, along with accompanying dates, can be arranged in chronological order and then plotted on the as-built in order to visualize the delaying events in the context of project history [Bramble et al. 1990]. Changes and delays are incorporated into the as- built through addition or alteration of appropriate activities.

Sources

- *bid documents*
- *contract documents*
- *computer-based multimedia sound, still, or video files*
- *cost and schedule data*
- *daily reports*
- *correspondence*
- *meeting minutes*
- *updated project schedules and progress reports*
- *payment applications or certificates*
- *testing records and reports*
- *submittal logs*
- *expediting and receiving documents*
- *concrete placement tickets*
- *change order data*

Information

- *actual start and finish dates for each activity*
- *delays*
- *actual project logic*
- *change orders*
- *extra work*
- *weather data*
- *labor job hours and head counts by craft*
- *equipment hours and types*
- *schedule of values information*
- *material quantities installed*
- *significant material or equipment received*
- *earned costs*
- *payment to date*
- *significant milestones reached*

Figure 3: Sources of Information used to Develop As-Built Schedule [Knoke et al. 1996]

The idea behind gathering all the information is to be able to recreate the job on paper, ideally in its entirety, so that future disputes can more effectively be resolved. However, the sources and information listed above are not always available for analysis. Contemporaneous documentation may not exist, may contain errors, or may omit important information. The importance of accurate contemporaneous documentation that records the facts is that it gives credibility to the history of the project [Knoke et al. 1996]. When disputes arise, courts look for detailed information gathered *throughout* the project, and not manufactured at project completion, most favoring an as-built record of construction that utilizes contemporaneous updates.

While the as-built schedule records all changes, it does not apportion responsibility or assign liability for delays [Clough et al. 2000]. After reviewing what goes into an as-planned (baseline) schedule, updated schedules of record, and an as-built, the following sections will discuss the sources and causes of schedule impacts, as well as how they are classified. Accurate schedule documentation in the as-built should include detailed records of all events that could have potentially impacted the schedule and project completion.

4 SCHEDULE IMPACTS

4.1 Understanding Schedule Impacts

Up to this point, the emphasis has been on developing accurate records of the execution of the project in its entirety. These records contain information on all events that will have a potential impact on the schedule and project completion. This section discusses the types of schedule impacts and the parties that cause them.

4.1.1 Types of Schedule Impacts

4.1.1.1 Delays

A *delay* is an event that prevents the contractor from completing the work within the contractually specified performance period [Wickwire et al. 2003], a slowing down of the work without stopping it entirely, triggered by something other than a formal directive from the owner to stop work [Bartholomew 2002]. Simply put, a delay is a loss of time. Any party involved in the project can cause delays, however most claims involve alleged delays caused by the owner.

Damages from pure delays are those resulting from an extended performance period, including increased overhead and job site costs, equipment standby costs, wage escalation, and financing costs [Wickwire et al. 2003].

4.1.1.2 Disruptions

A *disruption* can be defined as an impact that alters the contractor's planned work sequence or flow of work expected at the time of bidding, which results in increased difficulty, cost, and/or time [Bramble et al. 1990, Wickwire et al. 2003]. When this occurs, the contractor cannot perform work in the manner anticipated during bid preparation, thus resulting in a schedule impact. As opposed to delays, damages associated with disruption are likely to be increased labor costs due to inefficiency, the activation/deactivation of increased manpower, and additional equipment costs [Wickwire et al. 2003].

4.1.1.3 Change

Another major type of potential schedule impact involves *changes*. When a contractor takes on any type of work that deviates from the original contract, or from the scope of work or plan of action reasonably anticipated under the contract, that results in an increase in performance time, the contractor may seek an adjustment [Bramble et al. 1990]. Before determining the impact of the change on the schedule, the change must be identified as truly being a change from the original contract or merely a situation that should have been anticipated by the terms of the original agreement [Bramble et al. 1990]. Changes can be broken down into three categories:

Directed Changes: A classic directed change order involving a directed written modification to the contract (1) directs the contractor to make specific changes to the work required by the project plans and specifications, (2) acknowledges that a change has been made, and (3) invokes the directed contract change order provisions. The directed change to the contract should state the increase, or decrease in the case of a deletion, in total time for contract performance [Bramble et al. 1990, Bartholomew 2002].

Constructive Changes: An informal or constructive change lacks the formality of a directive authorizing a change in the work; "a change that is not acknowledged by the owner as such when it occurs, but which nonetheless is a change" [Bartholomew 2002]. The owner's action or inaction has an impact on the contractor, taking the position that whatever the contractor is directed to do or is prevented from doing is not a change, but rather is required or prohibited by the original contract, as the case may be. The contractor then proceeds with the owner's request for the constructive change, but then they must give prompt written notice of the constructive change to the owner. If courts rule that the contractor is correct in claiming a constructive change, the contractor will be warded the necessary time extension [Bramble et al. 1990, Bartholomew 2002].

Cardinal Changes: A cardinal change is a change (either directed or constructive) that is clearly beyond the general scope of the contract, so extensive as to change the entire character of the work required under the contract [Bartholomew 2002]. Such changes are illegal in public contracts, for although the owner and contractor may agree on the change, such a large addition of work violates public bidding statutes guaranteeing free and open competition [Bramble et al. 1990].

4.1.1.4 Suspensions

A *suspension* of work is a written directive by the owner to stop all work on the project, either because the contractor has failed to perform in accordance with contract documents, or at the owner's convenience [Wickwire et al. 2003]. Work will not continue until the owner has raised the suspension of work. A cost and time adjustment shall be made for any suspension of work ordered by the owner, as long as the contractor was not responsible for the suspension of work. As opposed to a pure delay, when an owner issues a suspension of work, the contractor is also entitled to equitable adjustment for profit [Wickwire et al. 2003].

4.1.1.5 Termination

Termination is a permanent stoppage of work of all or a portion of the contract, and the contract is terminated. For a party to possess the right for termination, a termination clause must be specifically included in the contract. Most contracts allow the owner the right to terminate the contract, while some contracts grant the contractor this right.

There are two categories of termination, the first type being *default termination*, which gives the owner the right to terminate the contract when the contractor's performance is either:

1. Far behind a reasonable time schedule or
2. Results in work that fails to meet contract quality requirements or
3. When the contractor becomes financially insolvent. [Bartholomew 2002]

The second type of termination, *convenience termination*, allows the owner to terminate the contract for its convenience, based on specific needs of the owner. For example, if the owner is unable to fund the remainder of the project and there is a termination for convenience clause in the contract, the owner is allowed to terminate the contract.

4.1.2 Causes of Schedule Impacts

4.1.2.1 Owner

The types of schedule impacts detailed above are directly attributable to different parties on the project, along with their causes of impact. While these types of impacts were discussed in generality, each party will now be discussed with specific examples of how they may cause schedule impact, beginning with the owner.

Disruption: An example of an owner-caused schedule impact is a disruption case where a contractor has approved plans to rehabilitate a two-lane bridge, with maintenance of traffic plans assuring all traffic will be detoured completely away from site. However, once construction has begun, the owner has a change of plans that involves maintaining one-lane traffic flow throughout the project. The contractor does not complete the project by the original contract completion date, as well as incurs added costs. This is an obvious case of the owner disrupting the contractor's planned work, resulting in a decrease in labor productivity.

Using the critical path method, contractors should plan work in the most economical, efficient manner. Owners and other parties to the contract oblige themselves not to interfere with the contractor's performance; however, they are not required to make unreasonable efforts to assist in performance [Wickwire et al. 2003]. For example, a building contractor should not assume that other crafts working in the same area should automatically yield to the contractor's demands.

Another issue concerning disruption is the ripple effect of an owner's disruption, or the negative effect on subsequent activities, creating additional delay [Wickwire et al. 2003]. For example, during construction of a building, an owner issues a change order to relocate heating vents; the direct effect of the change is the contractor must relocate the vents and reorder the vents if the air distribution performance criteria have changed. Equitable adjustment will be made for the direct costs of change – the new vents – however, this change will likely affect the contractor's other operations in the physical area of the change [Wickwire et al. 2003]. As shown, owner disruption can have both direct and indirect schedule impacts.

Additional Quantity: Another source of schedule impact is the case where additional *quantity* of work is required on existing activities – the same scope, but more of it. The increase in quantity of an activity directly affects the duration of the activity, consequently impacting the schedule. If greater quantities of work are needed to fulfill the contract, the contract time limit may be increased by means of one of the following two methods, selected at the discretion of the project engineer:

1. The extra time allowances as agreed on and set forth in the extra work order that covers the additional work, or
2. The same ratio that the total cost of work actually performed shall bear to the total cost shown in the bid schedule [VDOT Road & Bridges Specs, Section 108.09, 2002].

In the latter case, if a change order for an additional $50,000 of work is performed on an activity that the contract required $50,000 of work, the time allotted to this activity will be twice that as allowed by the contract, reflecting the ratio of actual cost to contract cost for that activity.

Differing Site Conditions: The first two sources of impact reflect the adding of scope and quantity to activities, whereas this section addresses a change in the conditions encountered on a job site, or *differing site conditions*. To be considered a Differing Site Condition (DSC), there must be a material, significant difference from the conditions reasonably anticipated to be encountered on site, in regards to one of the two following cases:

Type I Differing Site Condition – *contract misrepresentations.* A physical condition encountered on the site that differs materially from that represented in the contract documents. Two facts are needed to prove a Type I DSC. First, the contract documents must represent a physical condition in a certain way. Second, the conditions encountered during construction must be materially different [Bartholomew 2002]. A simple example is encountering underground rock where contract soil borings represent the location to be composed of sand. The rock differs from what was represented in the contract documents, therefore causing a Type I Differing Site Condition impact.

Type II Differing Site Condition – *reasonable expectations.* A Type II DSC is encountering an unknown physical condition, not represented in the contract documents, not normally expected in the type of construction work performed. It must be proven that such an encounter is highly unusual in this type of work. For example, a contractor encountering an unknown layer of asbestos when renovating a building: the contract documents did not inform the contractor of the hazard, therefore causing a schedule impact and extension to contract performance time [Bramble et al. 1990].

When a contractor encounters a DSC, it is essential that the owner is made aware of the situation before taking action and disturbing the DSC. Also to be noted is that during the contractor's pre-bid site visit and inspection, the contractor is required to inform the owner of any patent ambiguities between site conditions as they are represented in contract documents, and as found on site. Failing to do so can result in the contractor not being awarded for impact of the DSC.

4.1.2.2 Contractor

While this document focuses on determining what time extension, if any, shall be granted to the contractor, schedule impact analysis encompasses finding the impact of any event that may influence on-time, on-budget project completion. This includes actions on behalf of the contractor for which they are held accountable. The following is a list of possible events that cause contractors delays:

- Poor workmanship that causes rework
- Failure to supply the Four M's: Money, Materials, Machinery, Manpower
- Failure to coordinate subcontractors and lower-tier subcontractors
- Failure to perform job site investigate (pre-bid visits and geotechnical investigation)
- Project Manager or Superintendent's inability to manage crews
- General work slowdown; over-estimated productivity of crews
- Lack of construction "know-how"; contractor does not know what they are building, or not know how to build it
- Failure to account for "normal" weather
- Failure to follow contractual obligations

This list is not all-inclusive, for there may be more contractor-responsible events not listed that delay project completion.

4.1.2.3 Third Party / Force Majeure

Force Majeure schedule impacts are commonly known as unforeseen events, causes beyond the contractor's control, and events without fault or negligence. Common examples of delays that are beyond the control and without the fault of the contractor include but are not limited to:

- Acts of God or of the public enemy
- Acts of the Government in either its sovereign or contractual capacity
- Fires

- Epidemics
- Quarantine restrictions
- Strikes
- Freight embargoes
- Unusually severe weather. [Wickwire et al. 2003]

Under such provisions, the contractor is entitled to an extension of time to complete work if the delay is deemed *excusable*. An *Act of God* typically refers to a natural occurrence caused directly and exclusively by natural forces without any human intervention, which could not have been reasonably foreseen or prevented by the contractor or any other party to the contract. This category includes earthquakes, landslides, tornadoes, hurricanes, lightning, and floods. Liquidated damages are not to be assessed during this extended performance period, provided the delay is not directly or indirectly the fault of the contractor.

Abnormal weather conditions can greatly influence the execution of activities, in turn affecting completion of the project on time. Most contract documents state that the only weather that should impact the completion of the project within schedule is "unusually severe" weather conditions. Weather can have both a direct and indirect impact on construction. For example, if unusually severe rainfall amounts stop all earthwork activities, there is a direct effect and stoppage of work. In addition to the days that the rain has taken place, the indirect effect of the rain is that the earthwork activity cannot be started until the soil has dropped to a workable moisture content.

In dispute resolution, courts evaluate weather delays on a case-by-case basis, considering such factors as the job site's geographic location, the nature of the work performed, the contractor's previous experience in the area, and the contractor's reasonable anticipation of weather conditions [Wickwire et al. 2003]. Anticipating weather can be done by looking at historical data for typical "rain days" in the same geographic location, accounting not only for the time of year, but also for that specific location.

Weather impacts are not strictly limited to rain and the rainy season; also included but not limited to are abnormal humidity, frozen earth, winter weather, extreme heat, severe weather outbreaks, wind, and hurricanes [Bramble et al. 1987].

4.2 Classifying Schedule Impacts

Once recognized that an event has occurred in the as-built completion of a project that differs from the established schedule of record, which potentially has an impact on the schedule and is attributable to a party, the next step is to classify the delay, so that a schedule impact technique can be applied. Delays are classified into one of the following four categories:

1. Excusable, Non-Compensable Delays
2. Excusable, Compensable Delays
3. Non-Excusable, Non-Compensable Delays
4. Non-Excusable, Compensable Delays

Identifying the category of each delay is essential before applying a schedule impact analysis technique. Each of these four categories is attributable to the owner (ORD), contractor (CRD), or third party / force majeure (ED), and will be explained in further detail.

	Excusable	**Non-Excusable**
Compensable	**ORD**	**Some ORD**
Non-Compensable	**ED**	**CRD**

Figure 4: Classification of Delays

4.2.1 Excusable, Non-Compensable Delays (ED)

An excusable, non-compensable delay (when performing a schedule impact analysis, is shortened to an "Excusable Delay", or "ED") is a delay that will serve to justify an extension of the contract performance time, a cause of delay that is not attributable to either the contractor or owner. This includes all third party / force majeure causes of schedule impact. A contract may include risk-allocation provisions that define those types of project delays that are not attributable to either party, excusing them from meeting a contractual deadline. Should a dispute occur, courts, arbitrators, or boards of contract appeals will refer to the parties' contract as the embodiment of the agreement, and will attempt to enforce such provisions in accordance with the parties' intent. Prior agreements about whether certain delays are the risk of the owner or the contractor will, to a large extent, determine whether a delay in performance of work is excusable or non- excusable.

4.2.2 Excusable, Compensable Delays (ORD)

Excusable, compensable delays are classified as "Owner Responsible Delays," or an "ORD". An ORD, in addition to granting time extension, warrant monetary compensation to the contractor for extra costs incurred – commonly referred to as *delay damages*. Generally, compensable delays constitute a delaying event that is within the control of, is the fault of, or is due to the negligence of the owner. A compensable delay occurs when (1) the delay is caused by the owner or someone within the owner's control, (2) the delays results in actual monetary damages to the contractor, and (3) the contractor has not assumed risk to delay through a "No Damages for Delay" clause [Wickwire et al.
2003]. If such a clause should exist in a contract, the contractor is entitled to seek time extension for owner-caused delays, but not compensation.

On projects with contracts that do not contain a "No Damages for Delay" clause, the following is a list of possible compensable delays:

- Owner's failure to furnish the site to the contractor by an agreed date
- Faulty design
- Incomplete drawings and specifications
- Changes in scope
- Suspension of work
- Differing site conditions
- Late delivery of owner-supplied materials

When drafting the contract, the contractor may wish to include a clause specifically related to compensable delays (also referred to as owner-caused delays), which reinforce the contractor's right to recover damages under and express warranty. However, not doing so will not prevent the contractor from making future delay damages claims for compensable delays.

4.2.3 Non-Excusable, Non-Compensable Delays (CRD)

Delays caused by the contractor's actions and/or inactions are considered *non-excusable, non-compensable delays* – also referred to as a "Contractor Responsible", or "CRD." Non-excusable delays can be the fault of the contractor, his subcontractors, or suppliers. When such a delay occurs, the contractor is entitled to neither time extensions nor compensation. In fact, in addition to possible extra costs incurred by the delay of work, the contractor may be held liable for *liquidated damages* – a predetermined monetary amount that must be paid by the contractor to the owner for days in which the contractor delayed project completion. Liquidated damages are not meant to be a penalty, but a realistic estimate of additional costs to the owner caused by the contractor's delay.

It is often difficult for owners to ascertain non-excusable delays by the contractor because owners not always maintain construction schedules or records sufficiently detailed to identify either the contractor's delay or why it occurred. This downfall can be solved by keeping a detailed, updated construction schedule that establishes the start and finish dates for particular activities and field records that identify why a delay occurred.

4.2.4 Non-Excusable, Compensable Delays (some ORD)

The fourth classification of delay, *non-excusable, compensable delay*, is a peculiar situation in which an owner and contractor are concurrently delaying the project, and compensation for the owner's delay can be properly apportioned. While monetary compensation may be awarded, no time extension is granted for the period. The owner delay is shown on the schedule, however it is important to note in this situation that no time extension will be granted for the owner's delaying event.

4.3 Concurrency

4.3.1 Concurrent Delays

Not all delays occur independently of each other, often taking place during the same time and/or on separate parallel paths of the CPM network. Such delays are identified as *concurrent delays*, and require additional steps to properly apportion responsibility. To illustrate concurrent delays, a simple example of a theoretical project is described as follows. The example, which will be used throughout this document, is comprised of four activities and three delays that occur on the short project. The four activities are (1) the excavation of soil, (2) owner approval of drainage structure drawings, (3) installation of a new drainage structure, and finishing with (4) soil backfill. The as-planned (Figure 5) and as-built (Figure 6) CPM networks are represented, as well as an explanation for delays in the as-built (Figure 7):

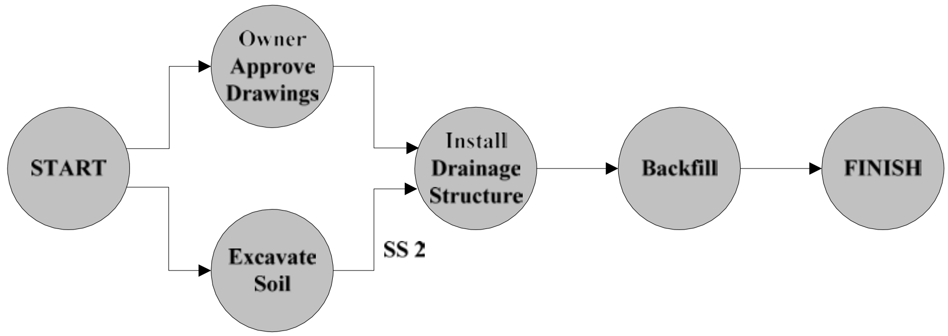


Figure 5: As-Planned CPM Network for Drainage Structure Example

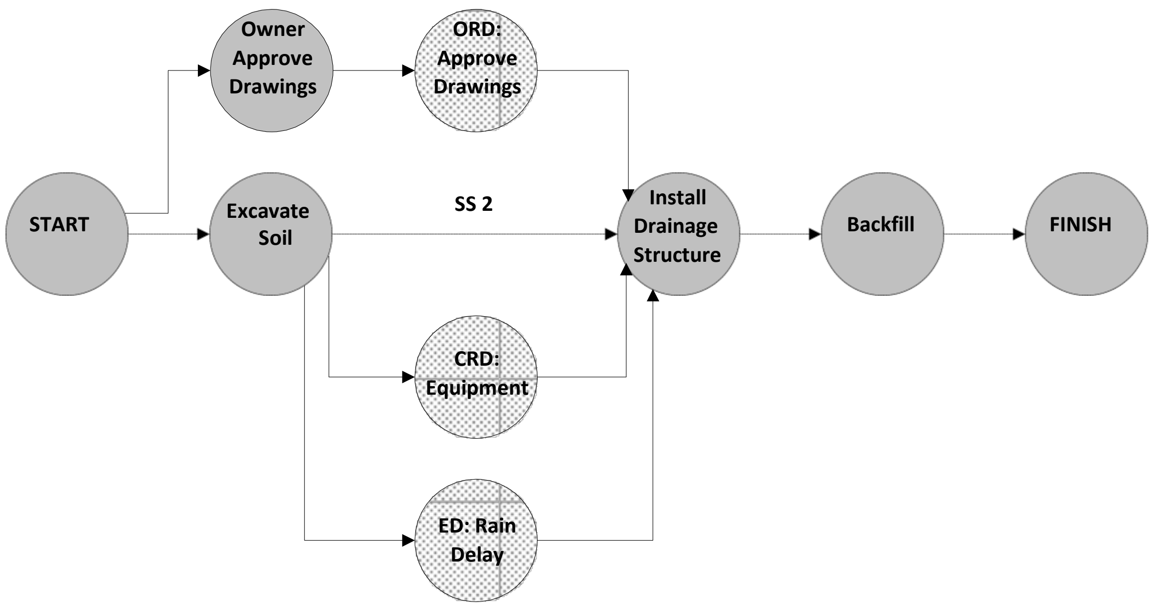


Figure 6: As-Built CPM Network for Drainage Structure Example

Owner Responsible Delay (ORD)	While excavation is taking place, the owner fails to approve drainage structure drawings in time to install drainage structure. The owner turns in the drawings 5 days late.
Contractor Responsible Delay (CRD)	Two days after excavation has started, when installation of the drainage structure should start, the contractor does not have the proper equipment on site required to install the drainage structure. An extra 4 days will be needed to get the equipment.
Excusable Delay (ED)	On the fifth day of construction, unusually severe rainfall begins, lasting 5 days. The result is a 5 day rain delay.

Figure 7: Drainage Structure Example Delays

As shown by Figure 6, the ORD, CRD, and ED are concurrent delays, occurring on parallel paths in the CPM network. These delays result in a setback of project completion that must be properly assessed to determine which party or parties are at fault, and if a time extension will be granted. This example shows a glaring need for a means for apportioning responsibility.

4.3.2 Apportioning Concurrent Delays

To illustrate concurrent delays in the most basic form, a bar chart of generic concurrent delays is shown in Figure 8. The *As-Planned* bars represent an approved as- planned schedule, accompanied by a *Planned Completion* date. The *As-Built to Date* represents completed activities to the present *Data Date*. Two separate delays occur at the same time on parallel paths in the network, Delays A and B. Based on the established schedule of record, each of these events in conjunction with what is left *To Build*, happening independently of each other, would have delayed the final completion of the project, *Delay*, to the final *Impacted Completion* date – as shown by *A* and *B.* Combining both delays onto one bar chart shows their collective impact on project completion.

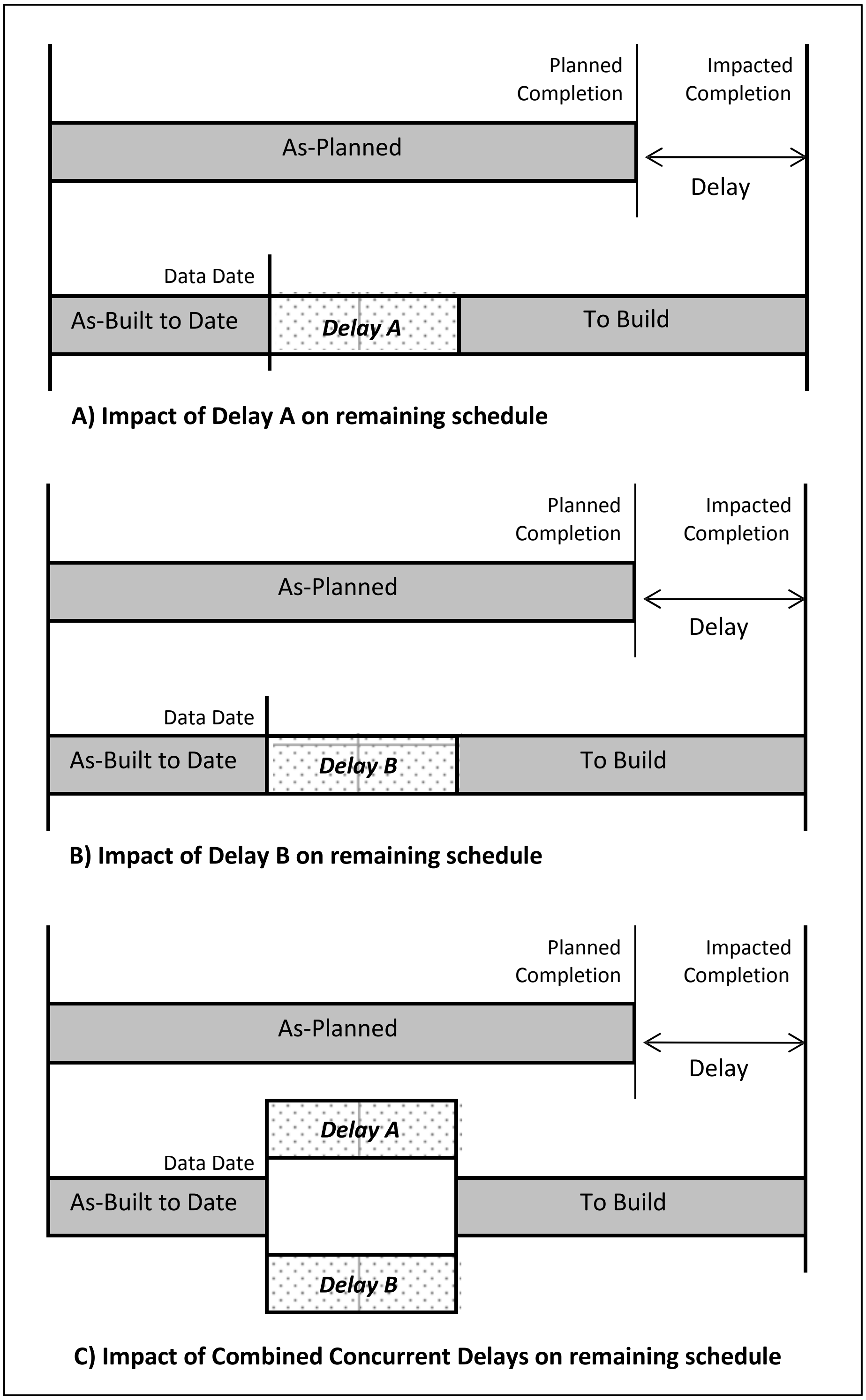
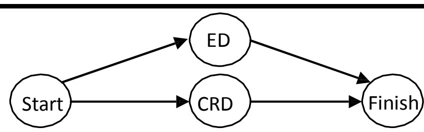
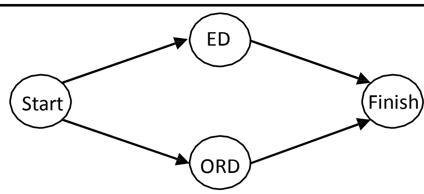
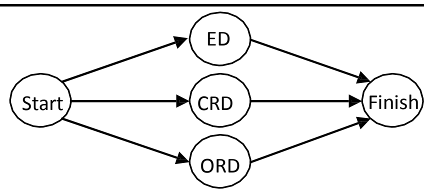
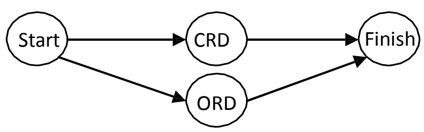


Figure 8: Concurrent Delays

As shown, two (or more) delays may take place concurrently at the same time and/or on parallel paths, making the process of apportioning responsibility more involved than merely identifying the delay that occurred. In both *A* and *B*, when each delay is inserted separately into the as-built schedule, the *Impacted Completion* date is affected the same amount of time. Diagram *C* shows that when both delays are inserted, the net impact is also the same. This raises the question of who holds responsibility for the impacted completion, and whether this should warrant a time extension.

Before a time impact analysis is performed, an understanding of concurrent delays is vital. The fact that two or more delays may occur at the same time and/or on separate parallel paths on the CPM network calls for methods to determine where time extension and compensation is warranted. In the event that two delays do occur at the exact same time on parallel paths of the CPM network, Figure 9 illustrates how apportioning of these delays may take place. It shows the four different concurrent delay scenarios that can occur between excusable delays, contractor responsible delays, and owner responsible delays. The general remedies that are commonly applied to these situations are listed on the right. The consensus of the figure is that any delay on the critical path acting concurrently with an excusable delay will warrant a time extension. In the event that both the contractor and owner cause a delay at the same time, the only remedy will be a time extension, without damages.

Concurrent Delay Scenario	**Remedy**
	Because ED is involved, the only remedy will be *time extension.*
	Because ED is involved, the only remedy will be *time extension.*
	Because ED is involved, the only remedy will be *time extension.*
	**Two options for remedy:** 1. Only *time extension.* 2. If able to apportion responsibility, *time extension* plus *liquidated damages* and/or *delay damages.*

Key:
ED = Excusable Delay
CRD = Contractor Responsible Delay
ORD = Owner Responsible Delay

Figure 9: Apportioning Concurrent Delays [de la Garza 2006]

Recalling our simple drainage structure example, and as commonly found in construction claims, varying party delays do not regularly take place at the same exact time, for the same exact duration, while on parallel paths – this is where a schedule impact analysis is needed. Terms of the contract, causes of the delays, timing and duration of the delays, the party or parties' responsibility for the delays, and availability of float are all major elements of performing a schedule impact analysis [Kraiem et al. 1987].

The following techniques address the resolution of concurrent delays and claims for time extension in their own separate ways, based on a combination of one or more of as-planned, as-built, and updated schedules.

5 SCHEDULE IMPACT ANALYSIS TECHNIQUES

After each delay has been isolated from other delays and assigned to one of the above categories, the next step is to identify when the delays occurred and their effect on project completion. To determine the total impact of the delay, one of the following schedule impact analysis techniques can be used:

1. Global Impact Approach
2. Net Impact Approach
3. Adjusted As-Planned CPM Approach
4. Adjusted As-Built CPM Approach
5. Collapsed As-Built (But-for) Schedule Approach
6. Impacted Updated CPM (Veterans Administration) Approach
7. Modification Impact Analysis (U.S. Army Corps of Engineers') Approach
8. Time Impact Analysis Approach [Bramble et al. 1990]

5.1 Review of Models

Introduction of the following eight different schedule impact analysis techniques including a brief walk-through of each method, which shows how they are applied and how they apportion responsibility for delays. The first five retrospective techniques look back on project delays once the project is complete, and then apportion responsibility, while the last three techniques analyze the effects of delay in a contemporaneous manner. The Impacted Updated (Veterans Administration) approach is both a retrospective and contemporaneous technique, in that it can be applied once all delays have occurred or at the time of delay.

The Global Impact and Net Impact approaches are considered completely illegitimate techniques, and if used to claim a time extension, should be rejected on grounds that they make conclusions on the effect of delays without considering any project logic. The remaining six techniques all use the CPM approach to scheduling, although some techniques use it more efficiently than others do. Figure 10 is a summary of these six techniques, whether retrospective or contemporaneous, and if based on the as-planned schedule or as-built schedule.

	BASED ON:	
	AS-PLANNED SCHEDULE	**AS-BUILT SCHEDULE**
Retrospective Techniques	**Adjusted As-Planned** *After the fact, inserting delays into the as-planned to quantify global impact.* **Impacted Updated (Veterans Administration)** *After the fact, inserting delays into an updated as-planned to*	**Adjusted As-Built** *After the fact, insert delays into as- built to show "critical path" and quantify global impact.* **Collapsed As-Built (But-for)** *After the fact, delays are*
Contemporaneous Techniques	**Impacted Updated (Veterans Administration)** *At the time of delay, inserting delays into an updated as-planned to quantify impact.*	**Modification Impact Analysis (USACE)** *At time of modification, schedule is updated and delay inserted to quantify singular impact.* **Time Impact Analysis** *Recreate time of modification.*

Figure 10: Schedule Impact Analysis Techniques Comparison

To better individualize each schedule impact analysis technique, consider the following train schedule example that analyzes a train's expected and actual arrival time (Figure 11). A planned (as-planned, baseline) train schedule is issued in January 2005, which is revised in January 2006. In June 2006, in an attempt to ride the train, it arrives late (actual train arrival). In January 2007, a revised (as-built) train schedule reflects the actual train arrivals from January 2005 through January 2007. The techniques found in Figure 11 will now be discussed from the bottom of the figure, up.

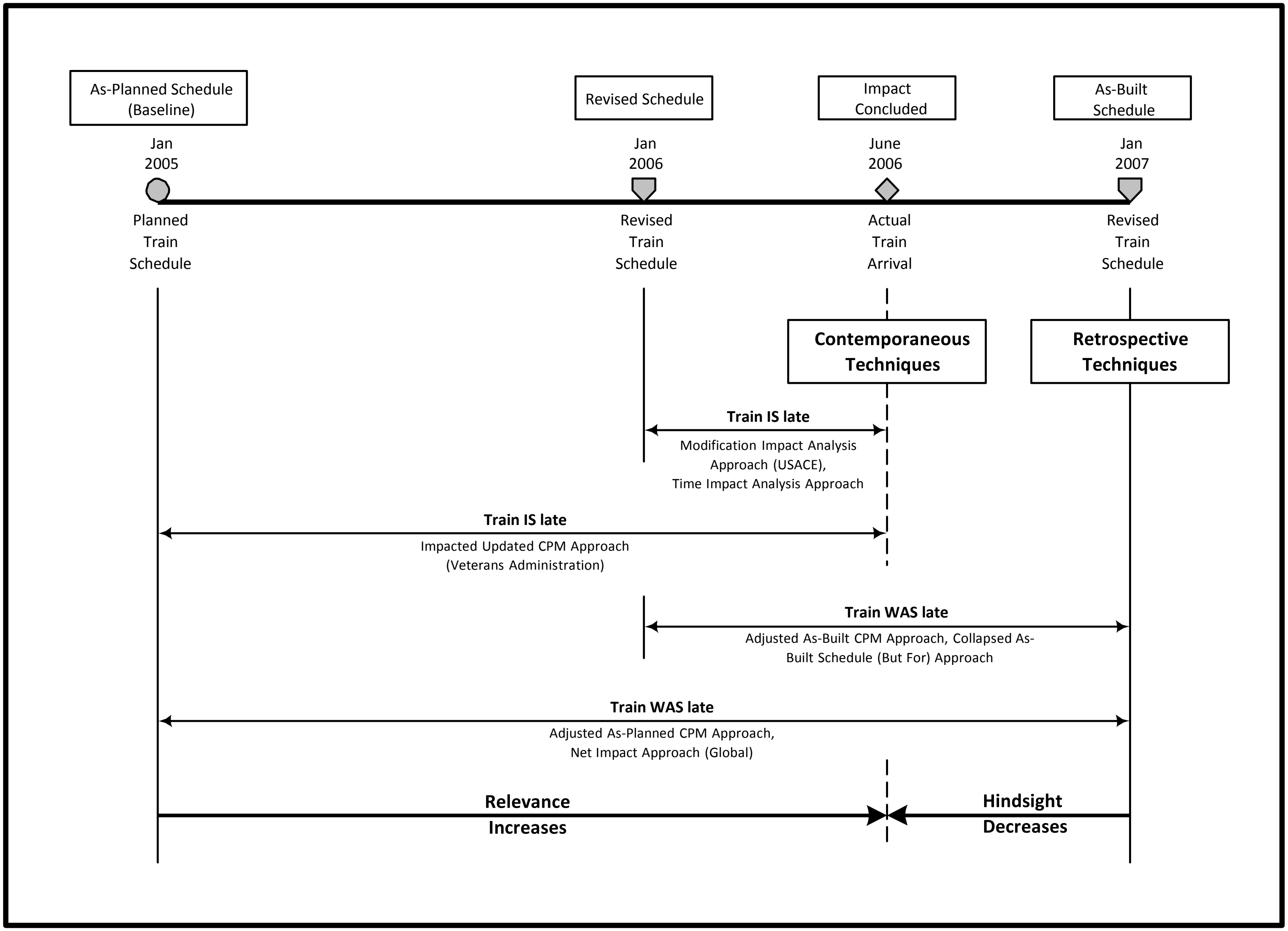


Figure 11: Train Schedule Example – TIA Techniques

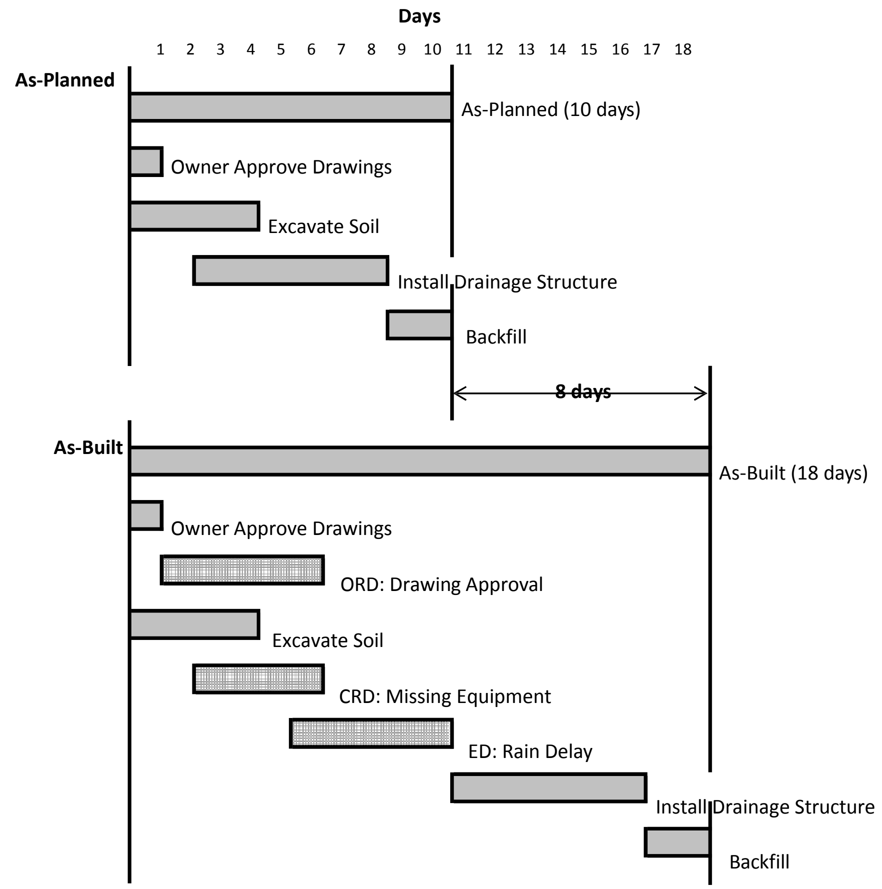
In January 2007, retrospective techniques will examine the impact of the June 2006 late train arrival. The Adjusted As-Planned and Net Impact approaches compare the late arrival of the June 2006 train to the original planned train schedule, released in January 2005. According to this schedule, the train was late, which it was, yet the original planned schedule is highly irrelevant compared to the revised schedule, released in January 2006. In addition to the irrelevancy of the schedule, perception of the event as it occurred is not as accurate as if it were analyzed at the time of the event.

While the Adjusted As-Built and Collapsed As-Built (But-for) techniques use the revised January 2006 schedule, they also use take a retrospective approach, analyzing the event in January 2007. Doing so incorporates a final revised schedule that was not in existence in June 2006, when the train arrived late.

Contemporaneous techniques will analyze the impact of the train being late at the present date, June 2006. The first attempt at a contemporaneous approach, the Impacted Updated (Veterans Administration) approach succeeds in analyzing the late arrival of the train, at the time of the event. However, the technique does not require periodic revisions to the schedule, or modifications to reflect the “as-built” schedule to date. The result is the use of the original January 2005 planned schedule as means for analyzing if the train is late. It is possible if, say, a train arrived late in February 2006, that this event would also be analyzed in June 2006, because this method does not require updates and analysis for each delaying event.

The Modification Impact Analysis (U.S. ACOE) and Time Impact Analysis approaches are contemporaneous techniques that analyze the actual train arrival in June 2006. Both techniques utilize the January 2006 revised train schedule, using the most updated, relevant information. Although the Time Impact Analysis approach is performed in January 2007, it determines the status of the train schedule in June 2006, as well as the actual impact of the event at that time. As shown by the figure, when compared to the previous approaches, the Modification Impact Analysis and Time Impact Analysis approaches analyze the actual train arrival in June 2006 with the most relevant schedule, all while minimizing hindsight. These methods give the most accurate analysis of when the train actually arrived in June 2006, compared to the most recently schedule time of arrival.

Each method will now be described with accompanying diagrams, which follow along with our drainage structure example, to illustrate how it is performed and how to apportion responsibility. Start, finish, and duration of the as-planned, as-built, and each delay activity are summarized in the following bar charts and table. Separate activities represent each delay and its accompanying duration, such as in the case of the owner's late approval of the drawings. Although the duration of the activity *Owner Approve Drawings* could have been extended to represent the ORD, making a separate activity of each delay distinguishes each delay and aids in the schedule impact analysis process. *Owner Approve Drawings* lasted for Day 1, followed in the CPM schedule by the remaining duration of the activity, as was delayed, from Day 2 to Day 6.



Activity	Duration	As-Planned Start	As-Planned Finish	As-Built Start	As-Built Finish
Owner Approve Drawings	**1**	**1**	**1**	**1**	**1**
Excavate Soil	**4**	**1**	**4**	**1**	**4**
Install Drainage Structure	**6**	**3**	**8**	**11**	**16**
Backfill	**2**	**9**	**10**	**17**	**18**
ORD: Drawing Approval	**5**	**-**	**-**	**2**	**6**
CRD: Missing Equipment	**4**	**-**	**-**	**3**	**6**
ED: Rain Delay	**5**	**-**	**-**	**6**	**10**

Figure 12: Drainage Structure Example Bar Chart and Delays

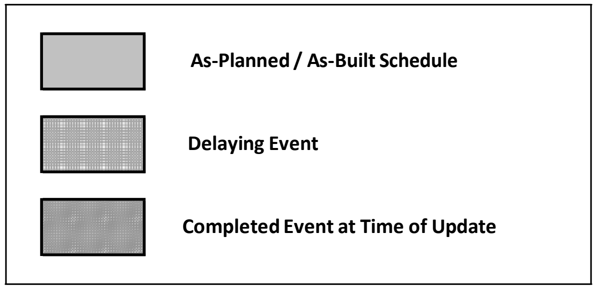


Figure 13: Diagram Key

5.1.1 Retrospective Methods

5.1.1.1 Global Impact Approach

Delay claims and time extension requests are not always put together in a calculated and precise manner, as exemplified by the global impact approach to schedule impact analysis. A claimant's initial request for time extensions, usually during the construction phase, ignores essential elements of scheduling. This approach lacks serious analysis and may lead one to believe that the claimant is not serious about the request.

The method involves plotting all delays, disruptions, and similar occurrences, of which the claimant is not accountable for, on an as-built bar chart. Start and finish dates of each event are determined, which follows by a calculation of total delay. The total delay to the project is the sum of the durations of all delaying events. Using the drainage structure example, Figure 14 shows the global impact approach method. The as-built duration is completed in 18 days, 8 days later than the as-planned duration. The contractor is making the claim for time extension, therefore accounting only for excusable and owner-responsible delays. These delays are plotted on the bar chart, showing the start, finish, and duration of each delay. Summing the durations of these delays results in a request for a total time extension of 10 days.

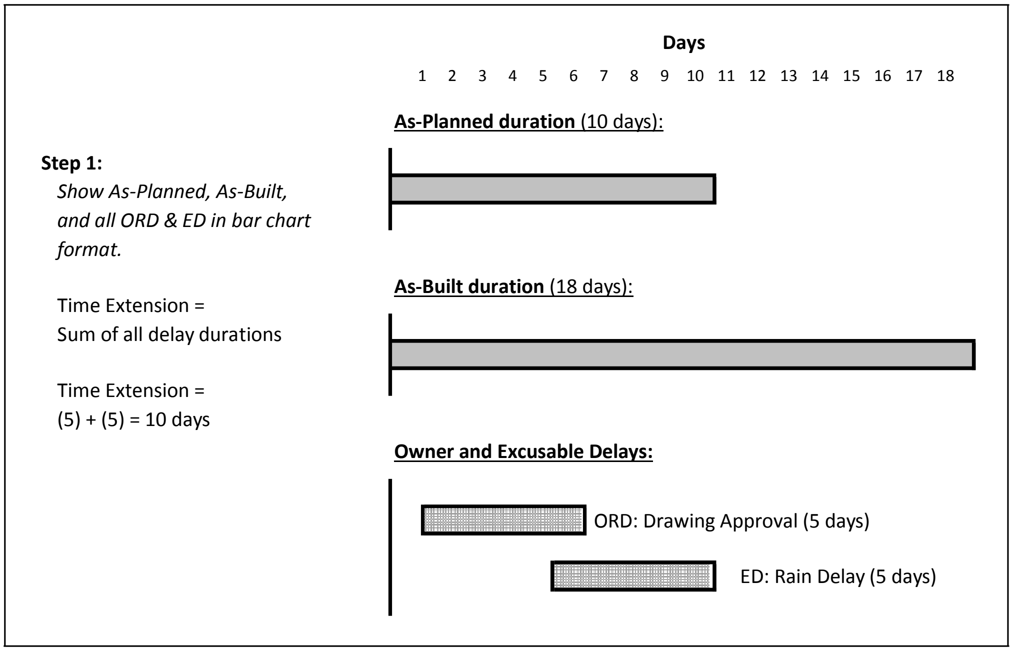


Figure 14: Global Impact Approach

The contractor has ignored concurrency between the delaying events, simply summing the durations of the delays. Two separate delays occurring during the same 9- day period should not yield an extension of 10 days. An additional fault in this method is that there is no attempt to analyze sequence of construction and how each delay affected the project completion. The frequent result of this approach is a claim for time extensions that extend well beyond the actual project delay [Bramble et al. 1990].

5.1.1.2 Net Impact Approach

The net impact approach attempts to account for the global impact approach's failure to assess concurrency through a technique that allegedly depicts only the net effect of all claimed delays on a bar chart. In this method, all delays and disruptions, including those of the contractor, are plotted on a bar chart, similarly as done in the global impact approach (Figure 15).

The figure below does show all three delays, yet, application of the net impact approach will most likely be used when there are a large number of delaying events. The widespread number of delays leads the claimant to argue that the only logical conclusion is that the combined effect of these delays is the net delay on the entire project. Although the start, finish, and duration of each delay are noted, their use is nonexistent. The contractor's request for time extension will be the difference between the as-planned duration and the as-built duration. In the example below, this duration is calculated to be

8 days.

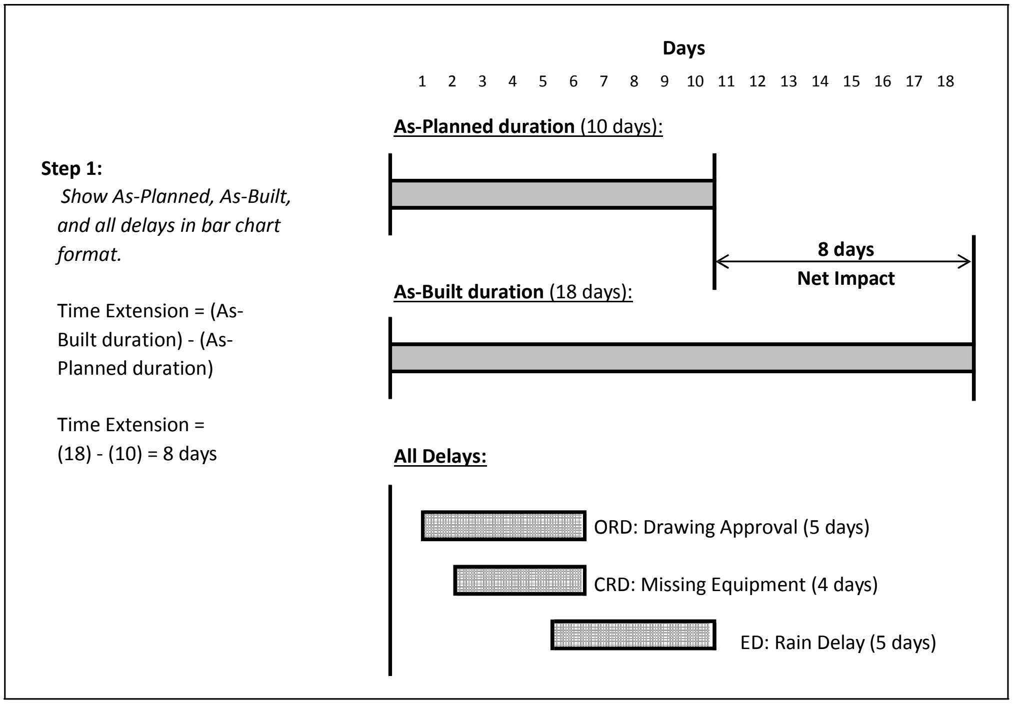


Figure 15: Net Impact Approach

Although the claimant has not counted parallel delays more than once, the individual impact of any delay is not calculated, rather assuming the total impact of all delays has a net effect on project completion. Without network analysis, such a method is nearly impossible to compute [Bramble et al. 1990]. The net impact approach fails to take into account any project logic – the main component of CPM scheduling.

5.1.1.3 Adjusted As-Planned CPM Approach

The first example of using a CPM network in schedule impact analysis is the adjusted as-planned CPM approach. The impact of delays is measured by inserting all contractor delays into the original baseline schedule. These delaying events are depicted as activities and spliced into the schedule. Actual progress and historical work activity data are ignored in this method. To calculate warranted time extension, CRD's are inserted into the as-planned schedule, resulting in an adjusted planned completion duration. Assuming this approach is performed retrospectively, the adjusted planned completion duration is then subtracted from the as-built completion duration (Figure 16).

In our example, the lone CRD of 4 days is inserted into the as-planned CPM schedule, leading to an adjusted completion duration of 14 days. The adjusted completion is then subtracted from the as-built duration to determine the amount of time extension warranted to the contractor. The contractor is awarded a 4-day time extension. The theory is that the contractor is taking responsibility for their delays, so the difference between the adjusted completion and as-built completion is not their fault.

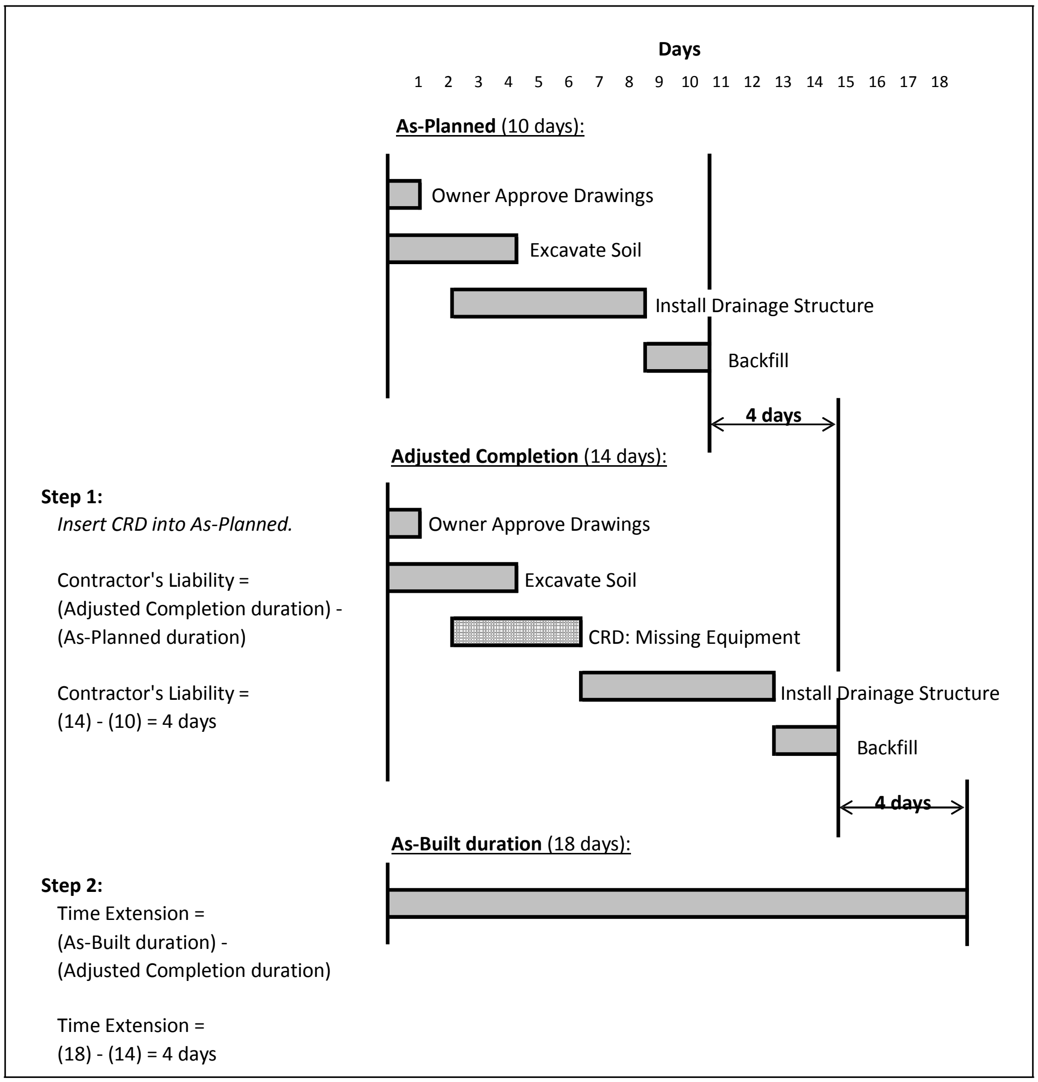


Figure 16: Adjusted As-Planned CPM Approach

The downfall with this method is that it ignores the actual construction progress and utilizes a theoretical schedule. It is possible that the original plan was unworkable and unrealistic, and may not have been followed. Furthermore, delays may have changed the critical path on an incremental basis [Bramble et al. 1990]. Without representation of changes in a schedule, relying on a very outdated train schedule is useless when looking back to determine if the train was late at some prior moment in time.

5.1.1.4 Adjusted As-Built CPM Approach

In a continuation of the adjusted as-planned CPM approach, the adjusted as-built CPM approach attempts to use the actual progress history with what appears to be CPM scheduling techniques. Activities linked in a network with restraints form an as-built schedule for the entire project, with delaying events shown as distinct activities. The critical path is determined only twice – once in the as-planned analysis and again at the end of the project. Not always, but a good way to rig the system is for claimants to tie the delaying events to what they identify as the "critical path."

As shown in Figure 17, an as-built CPM network is developed by inserting ORD's and ED's into the as-planned schedules, along with logical constraints. Rather than simply comparing the adjusted completion to the as-built completion date, this method shows a "critical path," attempting to hold the ORD's and ED's accountable for the delayed completion of the project. In our example, subtracting the adjusted completion duration from the as-built CPM network yields a time extension of 4 days.

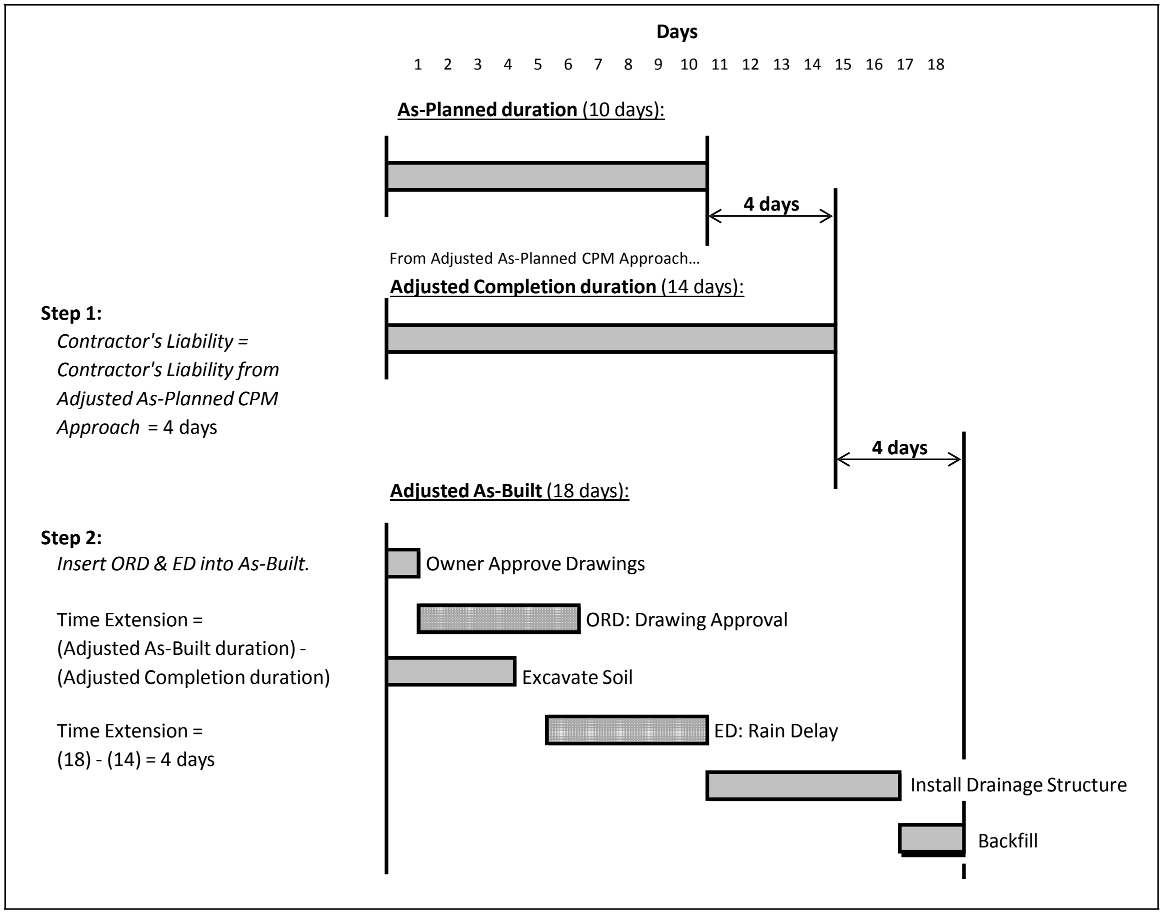


Figure 17: Adjusted As-Built CPM Approach

The calculation of the critical path is somewhat manufactured, since it is a one-time, after-the-fact calculation, rather than a contemporaneous analysis of the impact of each delay, at the time of the delay. CPM scheduling is intended to be a forward-looking technique used to predict the end of the job, not a method to establish the past; “CPM Schedule” and “as-built” are contradictory terms. When claimants use this technique, they generally will show only delays that are not their responsibility. They may acknowledge their delays on the as-built schedule in a way that appears the delays were not critical. Most importantly, no thorough effort is made to determine the individual impact of each delay on project completion [Bramble et al. 1990].

5.1.1.5 Collapsed As-Built Schedule (But-for) Approach

The collapsed as-built schedule impact approach utilizes the “but-for” technique. The owner and excusable delays are removed from the as-built schedule, “collapsing” the schedule, and demonstrating “but-for” the owner and excusable delays, the project would have been completed in a timely fashion. The technique is performed in multiple steps (Figure 18).

1. Once construction is complete, develop an as-built CPM schedule.
2. Remove ORD’s from the as-built CPM schedule.
3. The remaining duration represents what it would have been but-for the owner’s delays.
4. Subtract the “but-for the owner’s delays” duration from the as-built duration; the resulting days are solely the fault of the owner, warranting *x* amount of days of delay damages and time extension.
5. Remove ED’s from the schedule. The resulting schedule is what would have been had it not been for owner and excusable delays. The difference between this and the previous schedule is all attributed to the excusable delay – justification for *y* amount of days time extension. Using the formula shown in the figure below, quantify the impact of the contractor by solving for “Contractor’s Liability.”
6. Tally results from all steps.

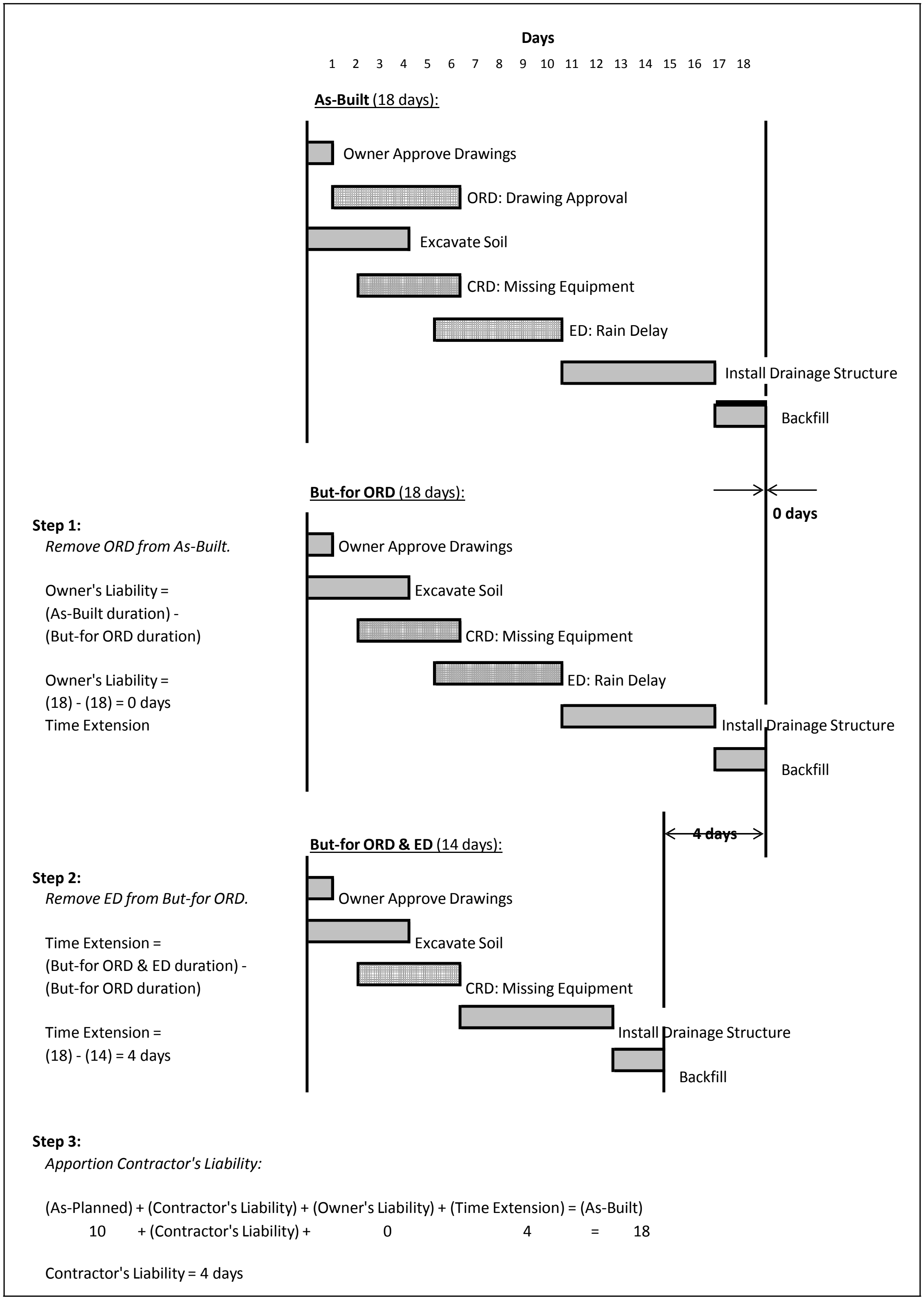


Figure 18: Collapsed As-Built Schedule (But-for) Approach

The collapsed (but-for) logic relies on the presumption of a hypothetical outcome from what the analyst says would have happened, had a portion of historical events not occurred. This method places too much weight on theoretical situation, not giving enough attention to cause and effect relationships. In addition, construction scheduling should reflect the schedule in light of current situations and cumulative events, not a retrospective subtraction of events is performed on a one time basis [Bramble et al. 1990].

5.1.2 Contemporaneous Methods

5.1.2.1 Impacted Updated CPM (Veterans Administration) Approach

Another approach to schedule impact analysis is the impacted updated CPM method, used by the Veterans Administration. The original project schedule, as updated, is used to measure delay. The analysis will take place often during the course of construction rather than after the project is complete. However, if the update information still exists, the technique may be applied after project completion. Each delaying event, not at the fault of the contractor, is analyzed to define where it should be inserted into the schedule. These delays are inserted into the currently updated and approved network diagram, as shown by Figure 19. Revisions to successive activities caused by the delay or change are determined by comparing the schedules before and after the changes have been incorporated. The effect that a delay or change has on the CPM schedule is determined by a comparison of the schedules before and after the delaying events are incorporated into the CPM Network; and only if the project completion is extended, the contractor is entitled to a time extension [Veterans Administration 1989]. In the event of concurrent delays, a single analysis must be made for all delaying events, rather than making separate calculations for each change.

Our example consists of concurrently delaying events, an ORD and ED, which are inserted into the most recently approve schedule, the original as-planned schedule. The result is an adjusted completion of 18 days, 8 days longer than the as-planned. The 8 days will be granted as a time extension.

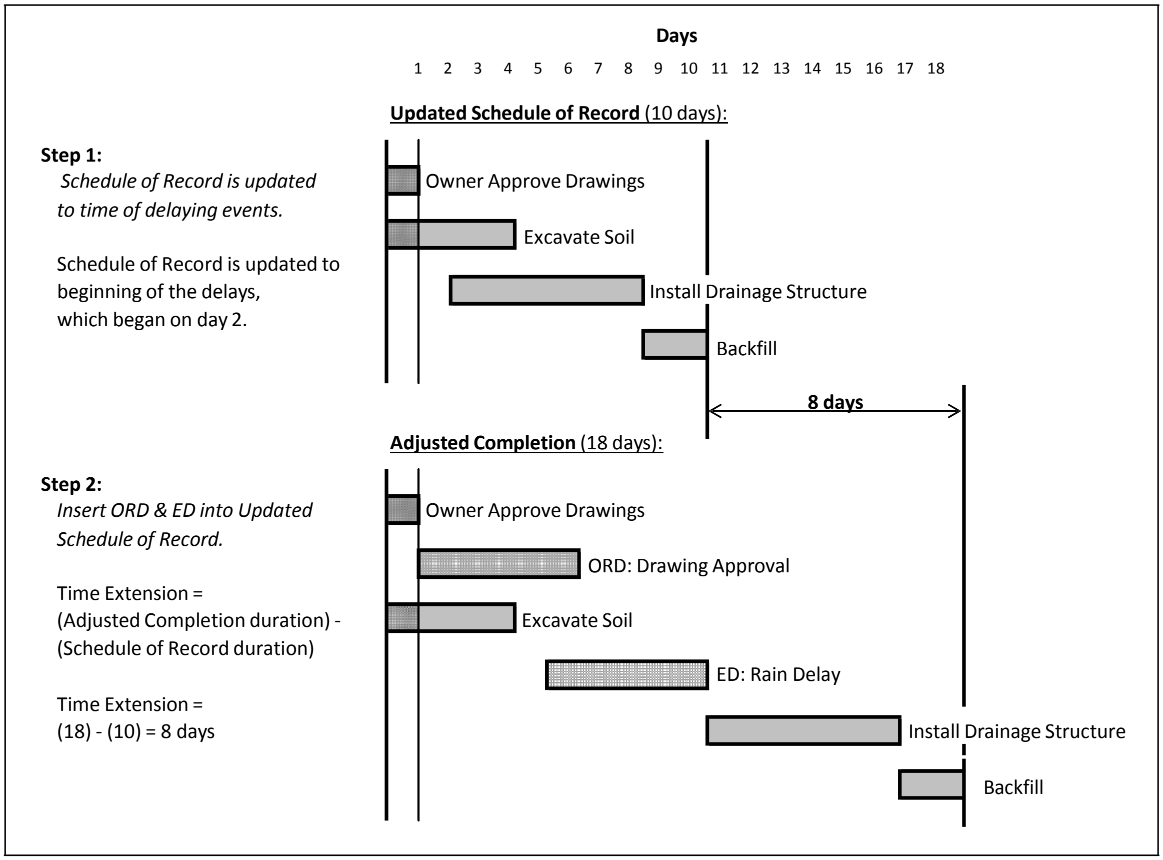


Figure 19: Impacted Updated CPM (Veterans Administration) Approach

This approach analyzes all delays that have occurred since the last update at one time, assuming that the project schedule, as updated and approved, is correct. It does not determine whether actual construction in the field differs from the approved schedule. This is another method that fails to properly use the CPM approach in a contemporaneous manner by updating after each delay [Bramble et al. 1990].

5.1.2.2 Modification Impact Analysis (U.S. Army Corps of Engineers') Approach

The U.S. Army Corps of Engineers' *Modification Impact Evaluation Guide* directs another method of schedule impact analysis. This approach can be broken down into three steps:

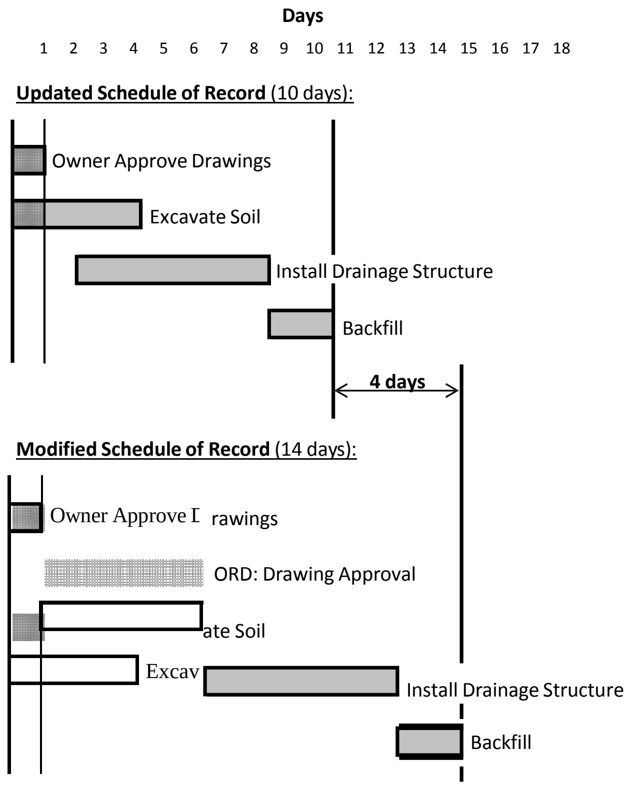
Step 1: The time impact analyst determines the actual status of the job when each owner or excusable delay occurred, without influence from the contractor's formal project schedule. This eliminates situations where the contractor's real plan may not be the same as indication in the schedule, or the schedule may not have been revised to reflect the effects of previous modifications.

Step 2: The effects of modifications or delay-causing events should be evaluated to determine which ensuing changes to the schedule must be made to accommodate these events. New activities may need to be created if all or part of the work does not fit into an existing activity.

Step 3: The schedule as revised is used for new calculations to determine the new critical path and project completion date. From this new completion date, time extensions and or delay damages can be granted.

Figure 1 evaluates the drainage structure example using the modification impact analysis method. Analysis of Delay 1, the owner's failure to approve drawings in time, begins with an updated as-built schedule at the start of the ORD (day 2). The ORD is then inserted into the schedule, making the proper modifications in the network to accommodate the change. Because the ORD is on the critical path, the result is the project being extended to a completion date of 14 days, granting 4 days of time extension and owner liability to the contractor. Delay 2, the 5 days of unexpected severe rain, starts on day 6 and last until day 10. Although the inclimate weather event is 5 days, the completion of the project is pushed back only 4 days, since this event is concurrent with the owner's untimely approval of the shop drawings. The critical path shifted from the owner's delay to that of the excusable delay. The result is granting 4 days time extension to the owner. The total time extension granted is 8 days, along with 4 days of owner liability.

DELAY #1:



Step 1:

Actual status of job is reflected in an updated Schedule of Record.

Schedule of Record is updated to beginning of first delay, ORD, which began on day 2.

Step 2:

Insert delay and create Modified Schedule of Record.

Owner's Liability =
(Modified SoR duration) -
(Updated SoR duration)

Owner's Liability =
(14) - (10) = 4 days
Time Extension

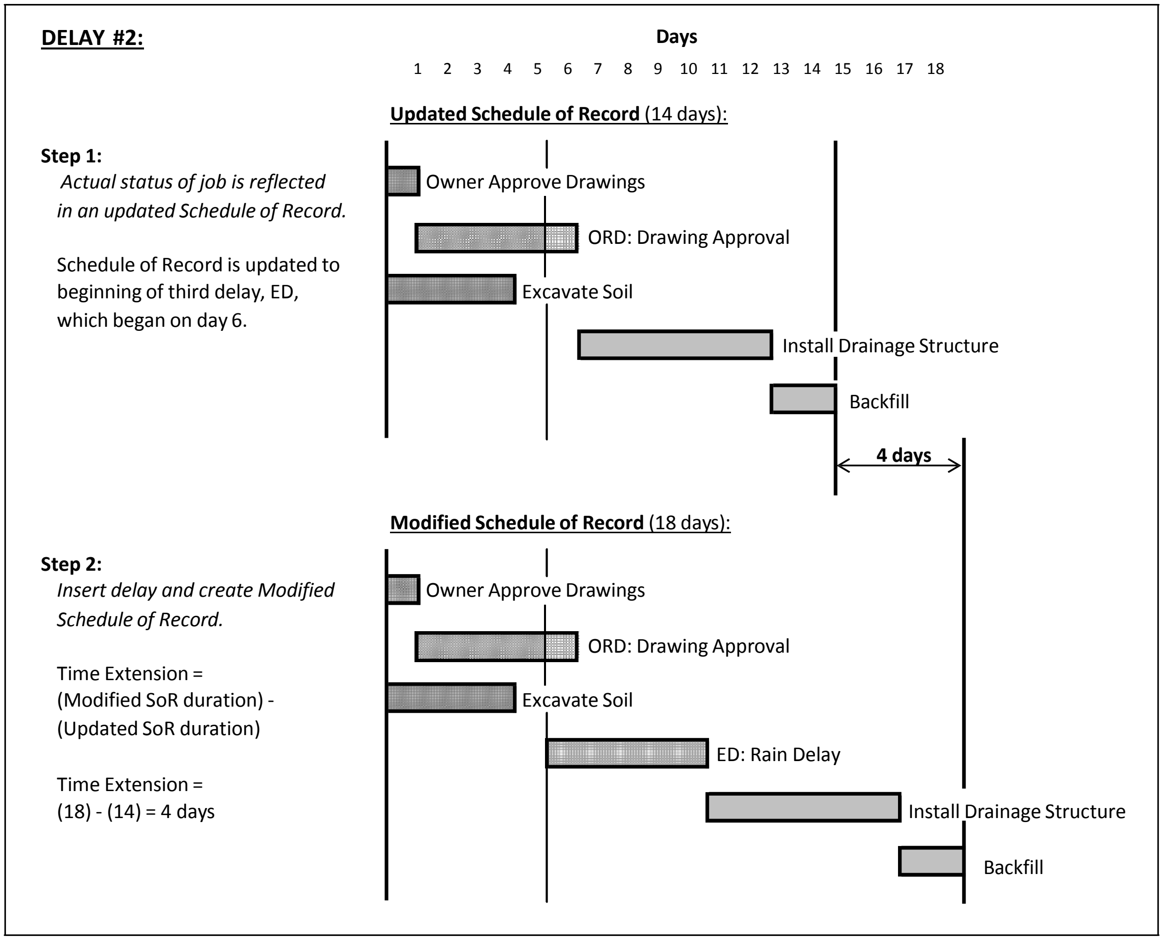


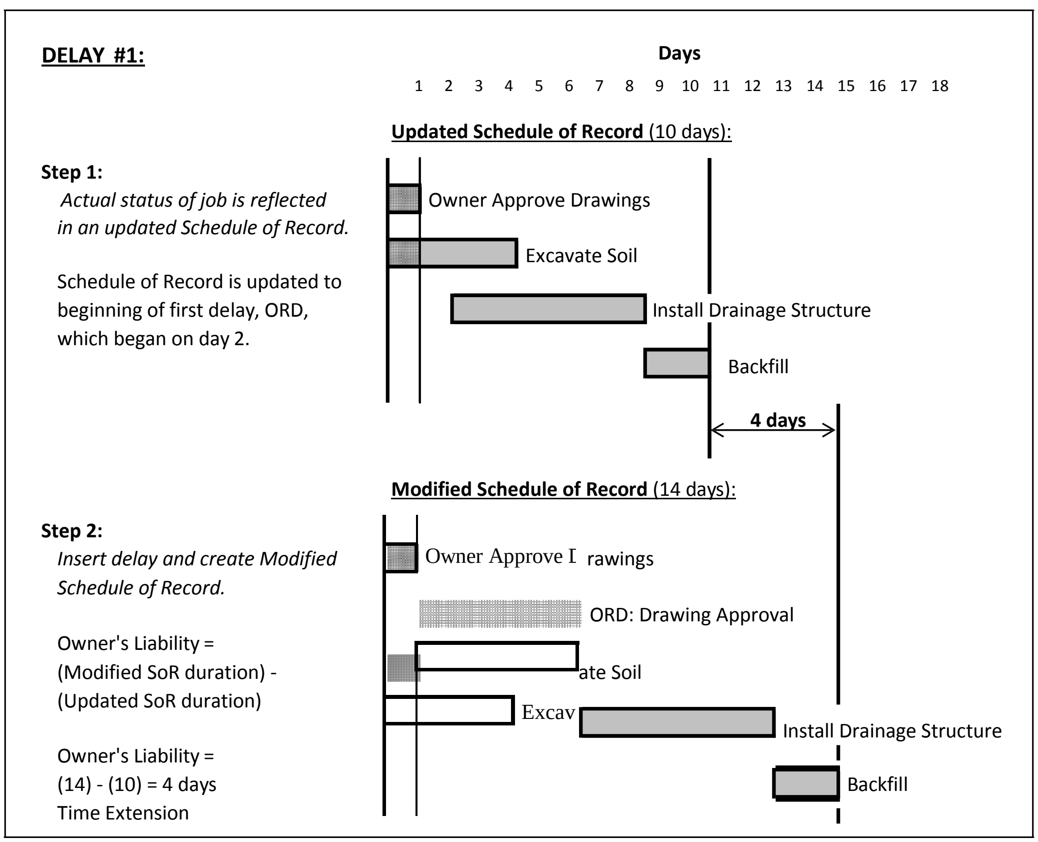
Figure 20: Modification Impact Analysis (U.S. Army Corps of Engineers') Approach

Particular to this method is that a schedule revision is required for each modification, ensuring that the project status is known and future changes predicted at the time of each possible delaying event. Adjustments to the schedule and impact analysis shall be performed at or near the time of the delay, not at the completion of the project. If there are no modifications or owner-caused delays or disruptions, then the contractor is solely responsible for late completion and is not warranted a time extension [Bramble et al. 1990].

5.1.2.3 Time Impact Analysis Approach

Of all the methods described, the time impact analysis method is the most comprehensive, incorporating the actual project history into a dynamic plan. Any delay, change, or disruption to the schedule calls for time impact analysis to isolate and quantify the event. To do so, a "picture" of the CPM network is taken when the event occurs, followed by inserting the change into the network. All variations that may occur in the schedule – such as the critical path may shift, float may be consumed, or new links between activities may be required – are analyzed to determine what the effect of the event is. Any additional or revised activities will be reflected in the as-built schedule.

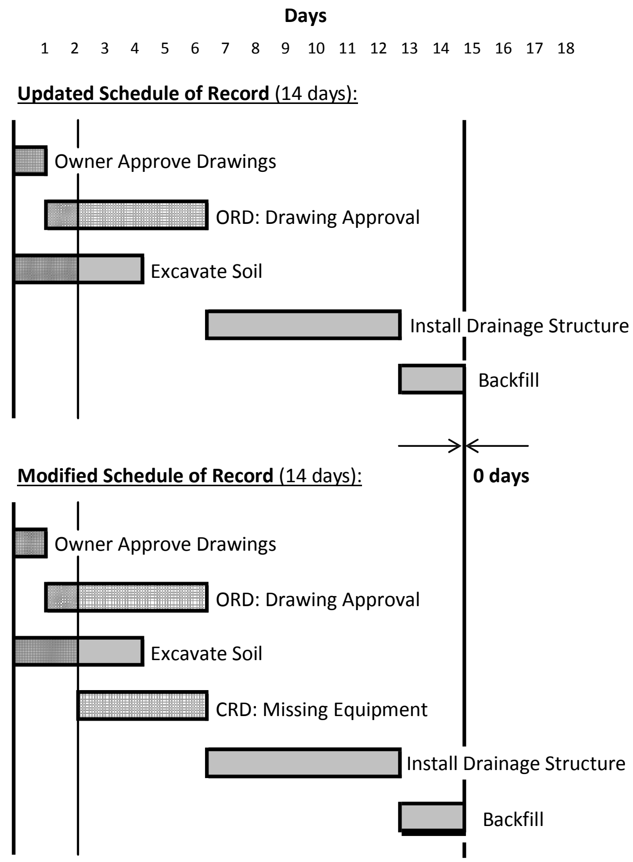
In the example below, Delay 1 is the owner's failure to approve the drawings on time (ORD). The schedule is updated to the beginning of the delay, day 1, the delay is spliced into the CPM network, and the adjusted completion duration is determined to be
14 days. These 4 days, the fault of the owner, are awarded as delay damages and time extension. On day 3, the contractor is unable to have the proper equipment on site to install the drainage structure, which shifts the critical path onto this CRD, resulting in an adjusted completion date of day 14. Because the completion date did not change, the contractor is not liable for any delay resulting from this event. Inclimate weather, Delay
3, further prevents the drainage structure from being installed. Once again, the critical path shifts, this time from the CRD to the ED, extending project completion an additional
4 days to day 18. These 4 days, because they are an excusable delay, are awarded as a time extension. The sum of damages and extensions are 8 days time extension, 4 days
delay damages, and 0 days liquidated damages.



DELAY #2:

Step 1:
Actual status of job is reflected in an updated Schedule of Record.

Schedule of Record is updated to beginning of second delay, CRD, which began on day 3.



Step 2:
Insert delay and create Modified Schedule of Record.

Contractor's Liability = (Modified SoR duration) - (Updated SoR duration)

Contractor's Liability = (14) - (14) = 0 days

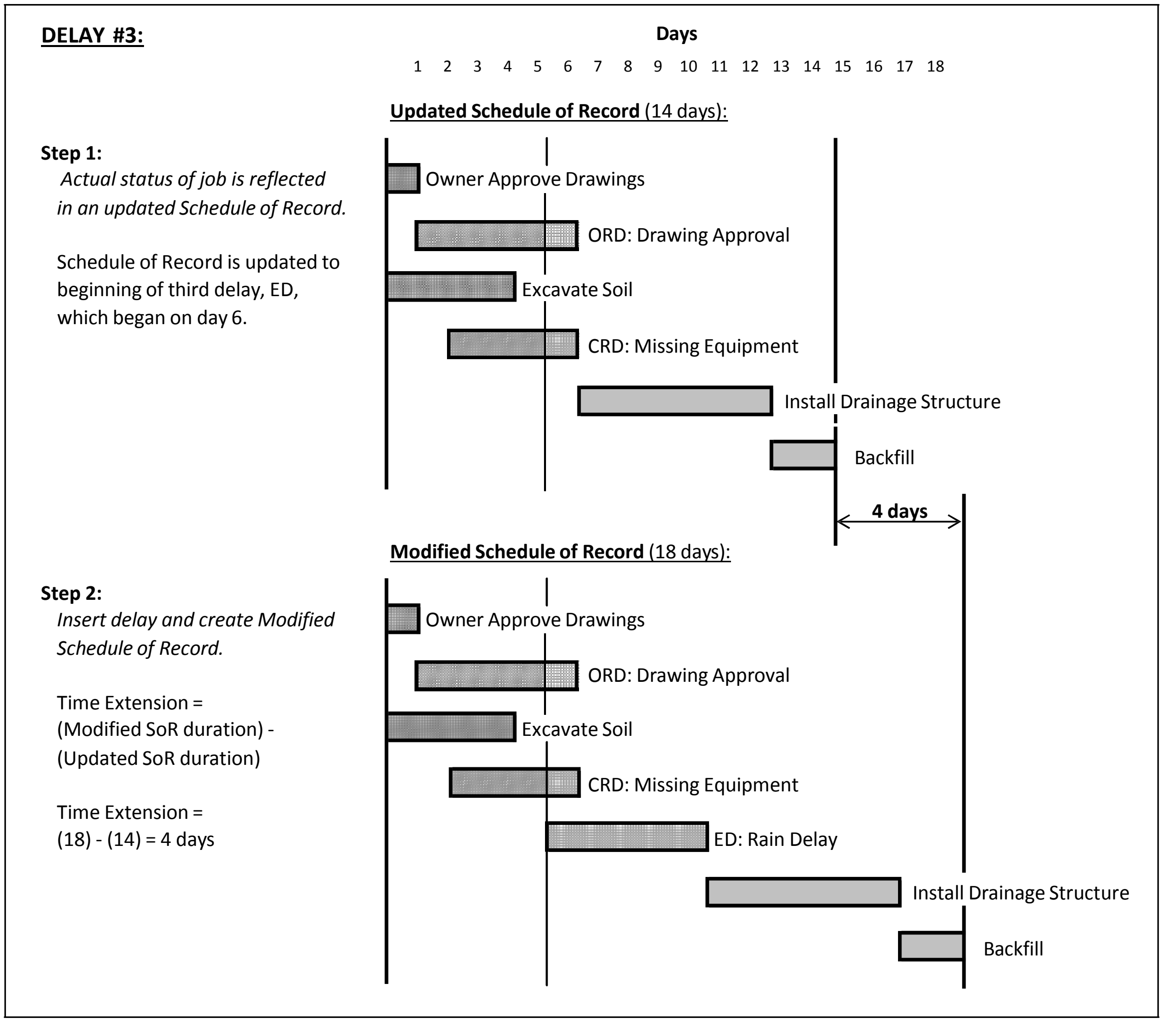


Figure 21: Time Impact Analysis Approach

The goal of the systematic time impact analysis approach is to give full consideration to the actual effect of events individually *and* acting together, and to evaluate the effect of ongoing delays. The goal of the method is to examine the evolution of the critical path and the impact of delaying events on that path [Bramble et al. 1990]. The time impact analysis approach is often the most time-consuming delay analysis method; however, it can be very accurate, has the potential to be the least controversial and most analytical, and can be equitable to all parties [Stumpf 2000].

5.2 Comparison of Methods

Figure 22 tabulates the results of each schedule impact analysis technique as applied to the drainage structure example. Although certain techniques apportion "owner liability" and "contractor liability", the focus is rather on determining what time extension, if any, the contractor is entitled to for delays.

Time Impact Analysis Technique	Time Extension	Owner's Liability	Contractor's Liability
Global Impact	10	*	*
Net Impact	8	*	*
Adjusted As-Planned	4	*	4
Adjusted As-Built	4	*	4
Collapsed As-Built (But-for)	4	0	4
Impacted Updated (VA)	8	*	*
Modification Impact (U.S. ACOE)	8	4	*
Time Impact Analysis	8	4	0

* this method does not assess this duration

Figure 22: Results of TIA Techniques for Drainage Structure Example

The actual project completed 8 days later than scheduled, yet time extensions ranged from 4 to 8 to 10 days. This discrepancy in contractor-awarded time extension is a product of the varying application of CPM schedules, as-planned/as-built schedules and techniques, and retrospective/contemporaneous techniques.

The trends found in the results do not however represent what will always be found when applying these techniques, i.e. But-for does not always warrant shorter time extensions, nor does Time Impact Analysis always warrant longer time extensions and owner's liability.

Disregarding the global impact and net impact techniques for their failure to apply CPM schedules, the remaining six techniques follow the equation for durations:

(As-Planned) + (Time Extension) + (Contractor's Liability) = (As-Built) The difference between our as-built and as-planned is 8 days, or the sum of the time extensions and contractor's liability for each technique. In other words, the duration that the project is delayed beyond the originally stipulated project completion date is a sum of the days that the contractor is liable and the days that the contractor is not liable.

Adjusted as-planned and adjusted as-built methods will yield the same results, since the adjusted as-built utilizes the adjusted completion duration found when using the adjusted as-planned technique. Time extension and contractor's liability are the same for our example, due to these methods' straightforward usage of the above formula, from a retrospective, analyze-all-delays-at-once approach.

Conversely, it is no coincidence that the modification impact and time impact techniques have identical results for time extension and owner's liability. The reason that there was the full 8 days of time extension, as well as 4 days owner liability, is the order in which delays took place on the project. The beginning of each delay marks which delay rules in a situation where there are concurrent delays. Because the owner was not going to be able to approve the drawings for an extra 5 days, this created 4 days of float in which the contractor was unable to provide the proper equipment to install the drainage structure.

The modification impact and time impact methods are one in the same, except for that the modification impact does not assess contractor's liability. The reason for this is that once determining inserting a delay and updating the CPM schedule, the modification impact analysis requires the analyst to "note any slippage of final completion date [and the] difference is amount of time extension justified because of impact" [Department of the Army 1979]. No mention is given to awarding damages to the contractor or assigning contractor's responsibility. For this reason, it is assumed that this method was not intended to be used to award contractors damages. However, the method is nearly identical to that of the time impact analysis technique, and if contractor delays were considered in analysis, contractor's liability could easily be assessed.

6 SUMMARY AND RECOMMENDATIONS

Each project starts with a plan – the *what, how, where* and in *what order* – of the matter in which work will be completed. The plan is then given greater detail – the *who* and *when* – that develop the baseline schedule, or the contractor's original understanding and plan of action for the project. Once the project commences, schedule updates and revisions – whether at scheduled intervals or as result of a change – create new schedules of record that shall meet the owner's approval. Eventually, the final schedule of record will be the as-built schedule – a final documentation of actual starts and finishes of activities, any delays, change orders, extra work, weather, and other factors that affected project completion.

Events that influence project completion are of various type, including delays, disruptions, change, suspension, and termination. One of three parties is responsible for these sources of schedule impact: the owner, the contractor, or a third party not to be at fault of the owner or contractor. When classifying delays, those caused by a third party, such as unusually severe weather, are "excusable delays" and warrant time extensions to the contractor. Owner responsible delays are "compensable" delays, and in addition to rewarding the contractor time extension, may involve delay damages. On the other hand, when the contractor is responsible for a delay, it is a "non-excusable delay", and not only is the contractor declined a time extension, but they may also be held accountable for liquidated damages.

These different types of delay do not always take place independently of each other – "concurrent delays" happen at the same time and/or on separate parallel paths of the CPM network. As shown by the drainage structure example, properly apportioning responsibility and awarding time extensions and/or damages for delays, even for a very simple example, requires more than a rudimentary process.

Each of the eight time impact techniques as described in full detail give an overview of how each is applied, its strengths, and in many cases, its weaknesses. The comparison of time impact methods emphasizes using the most relevant, updated, and revised schedule, while minimizing hindsight – a contemporaneous method based on the as-built schedule that is a true representation of the actual project. Such a formula is considered the most comprehensive and accurate means for determining the impact that delaying events have on the schedule and project completion.

This document recommends the use of the *modification impact analysis technique*, as described by the U.S. Army Corps of Engineers' Modification Impact Evaluation Guide, which is summarized in three steps:

1. Determine the actual status of the job when the delay occurred
2. Analyze the scope of the modification to determine which activities will be directly affected, and modify schedule to accommodate affected activities
3. Use revised schedule to determine new critical path and completion date, which may issue a time extension and/or damages.

Although the *modification impact analysis technique* is preferred, if evaluation of the delaying event cannot be performed at the time of the delaying event, use the *time impact analysis technique* to go back to the schedule that would have existed at the time of the delaying event. This technique is nearly identical to that of the modification impact technique, only differing in that it recreates an "updated" schedule that most closely reflects the actual status of the job when the delay occurred, retrospectively creating a contemporaneous "snapshot" of the project at the beginning of the delaying event. The advantages of these preferred techniques over all others described are that the modification impact and time impact analyses use the most recently updated, relevant schedules and project information, at the time of delay, reducing hindsight that can be created when evaluating claims well after pertinent events have taken place.

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