فرآیند جامع آنالیز تاخیرات در پروژه

بخش ششم:
آنالیز زمانی تاخیرات

آنالیز تاخیرات در شرایطی که تنها Gantt Chart در دسترس است!

ارائه دهنده:

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What we will learn?

- Gantt Chart
  - Introduction
  - Major shortcomings
- How to perform delay analysis using Gantt Chart?
  - Step 1: Identifying the critical path on a Gantt Chart
  - Step 2: Quantifying delays using Gantt Chart
  - Example 1
  - Example 2

Introduction

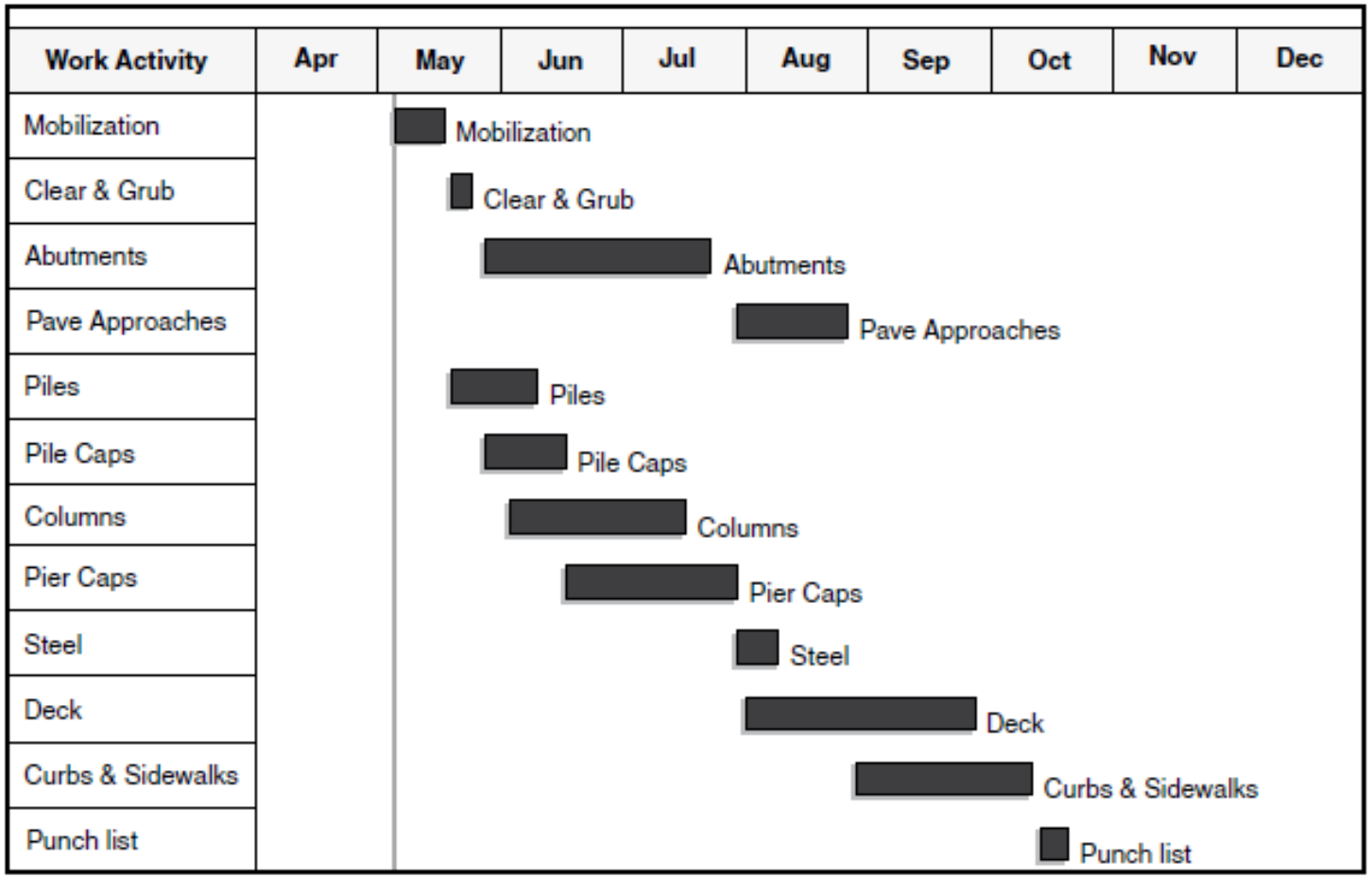
- **Many projects** are **scheduled** using a **Gantt Chart** **even though** with a **complex project**, a Gantt Chart is **not as desirable** as a **CPM schedule**.

- There is **nothing inherently wrong** with **scheduling** a project with a **Gantt Chart**.
  - A **detailed Gantt chart** can provide **almost as much information** as a **CPM schedule**.

- **One** should still **perform a meaningful** analysis using a **Gantt Chart**.
  - However, as the **level of existing detail** and the **quality** of **information decrease**, the **delay analysis** becomes **more subjective**.

Gantt Chart

- **Gantt chart** shows the **general sequence of work**
- The **project manager** can easily **define each activity** in **more detail**



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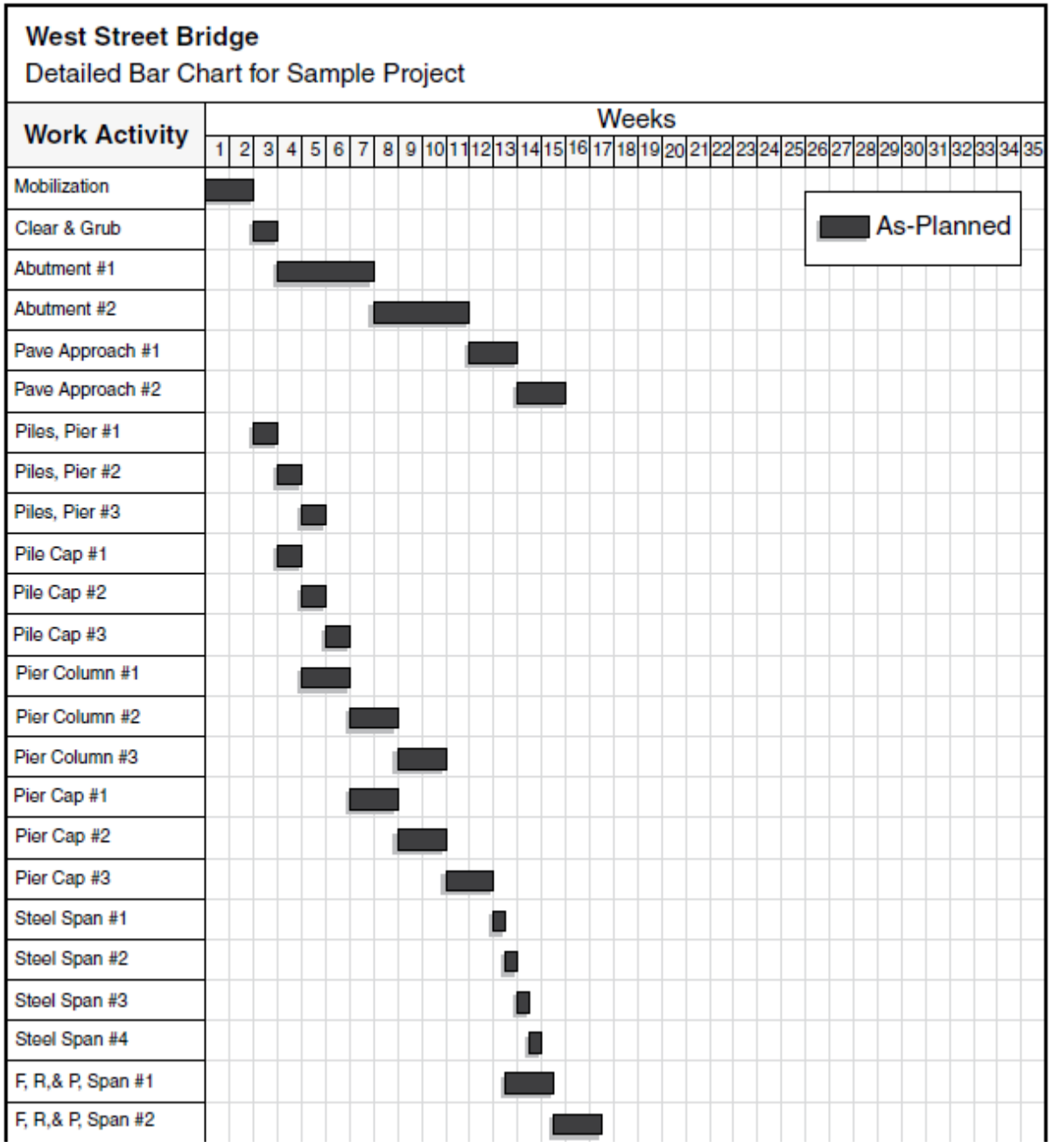
Gantt Chart

- The **figure** below is a **more detailed Gantt Chart** for the one shown in **previous slide**.



By: Alavipour, PhD, PMP, CMIT

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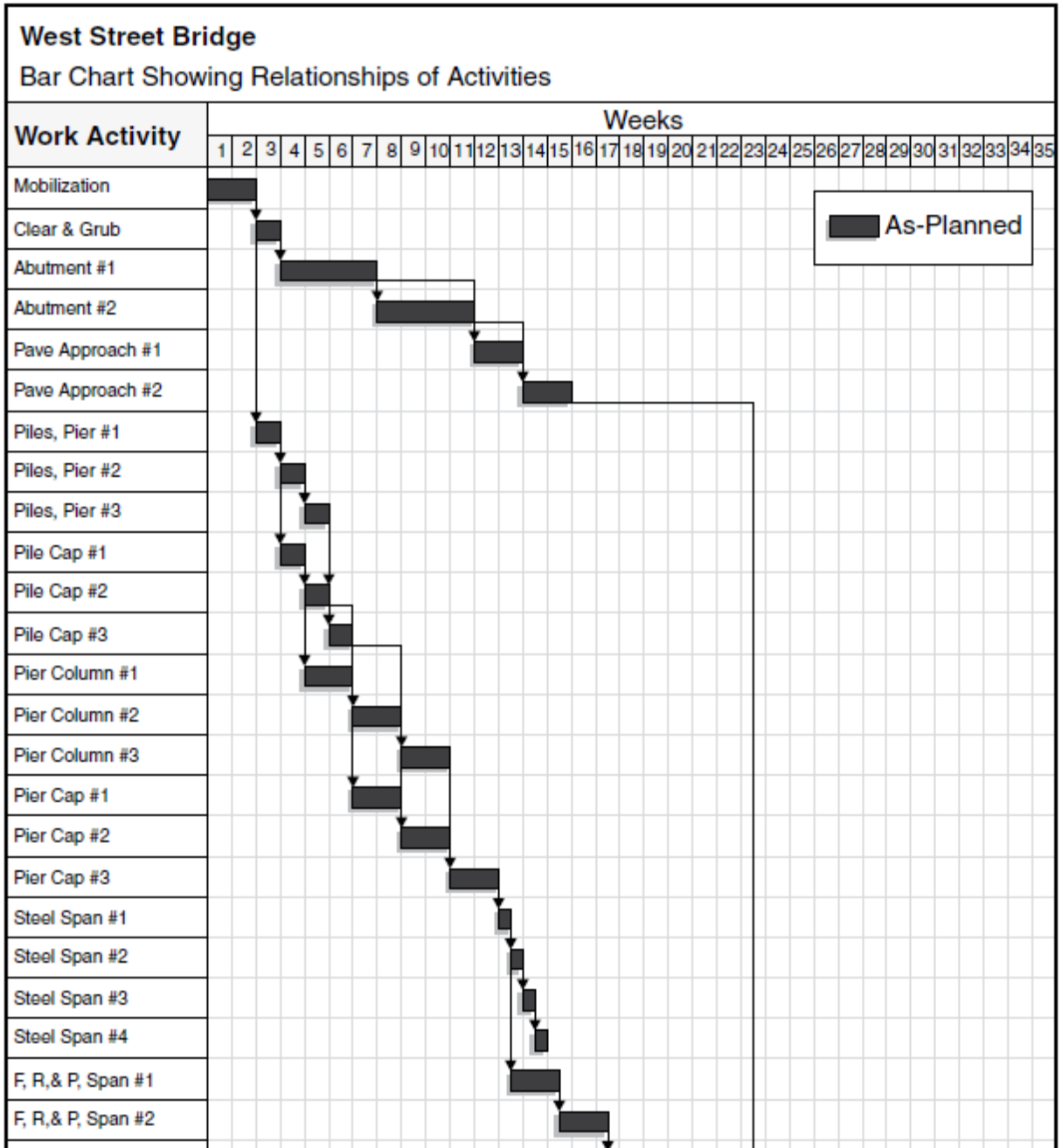
Gantt Chart

- With **very little effort**, the **project manager** or **project scheduler** can modify the **Gantt Chart shown in previous slide** to **show interrelationships** among the activities as **shown in this figure**.
- With **minimal effort**, one could **produce** a **CPM schedule** for the project.



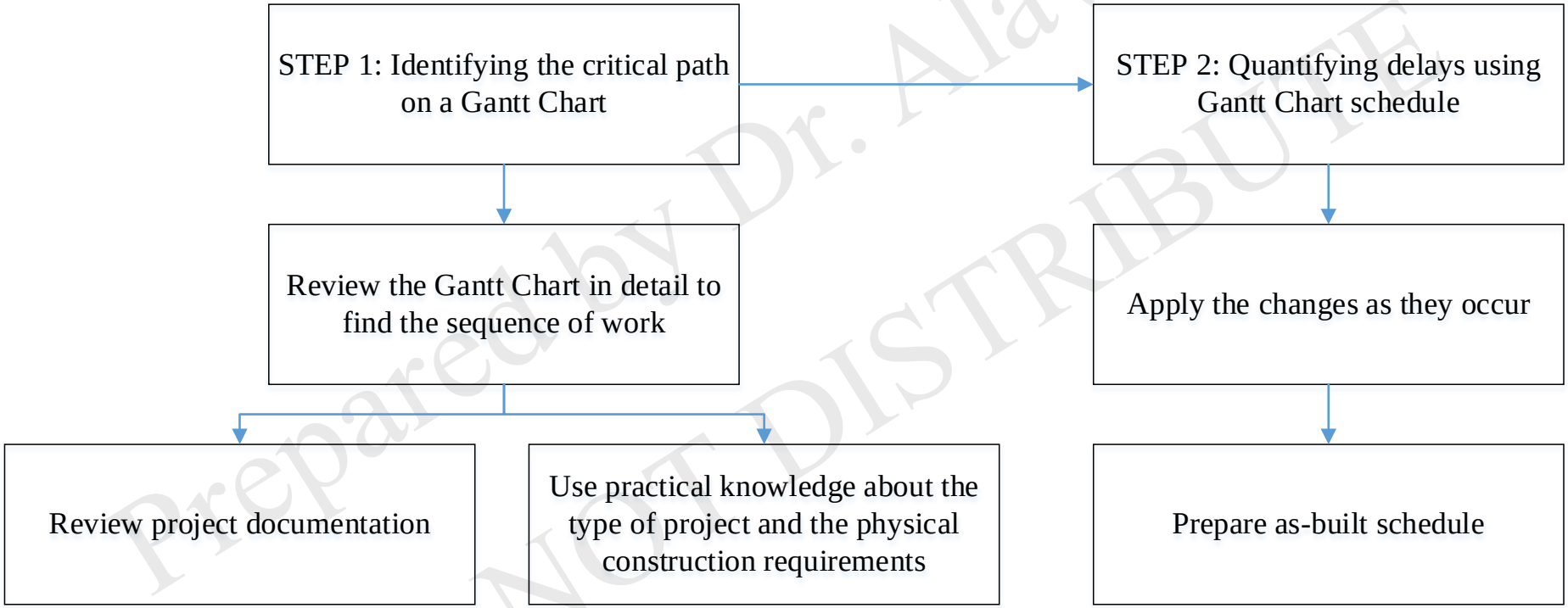
Gantt Chart – Major shortcomings

BUT

- **Most projects** that use **Gantt chart do not include** as **much detail** in **their Gantt chart**.
- **Major shortcomings** that **diminish** the **usefulness of Gantt chart** as a **(1) management tool** and **(2) tool for measuring delays**:
  1. **Lack of detail**—**too few activities** for the amount and **complexity of the work**
  2. **No indication** of the **interrelationships among the activities**
  3. **No definition** of the **critical path** of the Project

Obviously, these weaknesses hamper the ability of the analyst to perform a delay analysis, but they do not make it impossible.

How to perform delay analysis using Gantt Chart?



STEP 1: Identifying the critical path on a Gantt Chart

- The **first step** in analyzing a **Gantt chart** is to **define the critical path**.
  - **Every Project** has a **critical path**.
  - **Even** if a Project **does not** have a **CPM schedule**, it does **not mean** that it does **not have a critical path**.
    - ✓ **Critical path** is the **longest path of work activities** through the **network diagram** that **control** the **project completion date**.

Whether the critical path is defined in a CPM schedule or a Gantt chart, every Project has a series of interrelated activities that will control the Project completion time.

STEP 1: Identifying the critical path on a Gantt Chart

- The **analyst must review** the **Gantt chart** in **detail** for **obvious conclusions** about the **sequence of work**.
  1. The **review** should be based on **project documentation** that might **clarify** the **thought process** that:
     - **(1) Went into creating** the **Gantt chart**
     - **(2) Defining** the **planned work sequence**
     - **Documentation** that can be **helpful** includes:
       1. Contract documents (which may dictate staging or phasing)
       2. Preconstruction meeting minutes
       3. Internal Contractor documentation
       4. Project correspondence

Find contractual logic

STEP 1: Identifying the critical path on a Gantt Chart

- The **analyst must review** the **Gantt chart** in **detail** for **obvious conclusions** about the **sequence of work**.

2. **Practical knowledge** of **(1) type of Project** and **(2) physical construction requirements** is also **necessary**.
   - For example, to analyze a **Gantt chart of a high-rise structure**, the **analyst must know** that **interior finishes usually cannot start** until the building is **"constructed."**

Find Mandatory and Discretionary logic

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STEP 1: Identifying the critical path on a Gantt Chart

- The **analyst must review** the **Gantt chart** in **detail** for **obvious conclusions** about the **sequence of work**.

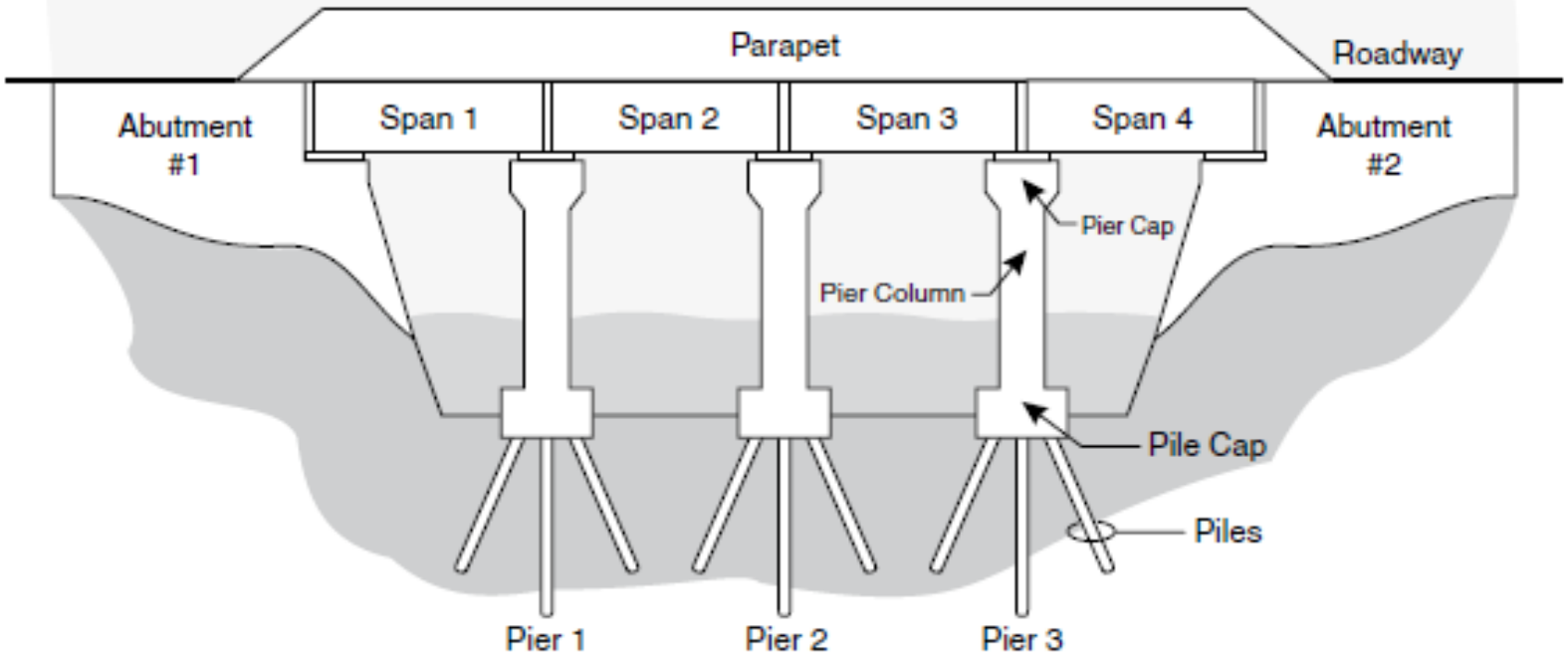
A note of caution:

The analyst should resist the temptation to interpret the Gantt chart schedule based solely on his or her own experience.

Merely because one has performed work in a particular sequence in the past does not mean that the Contractor on the Project being analyzed has planned it the same way.

Now, the critical path is identified!

STEP 1: Identifying the critical path on a Gantt Chart – Example 1



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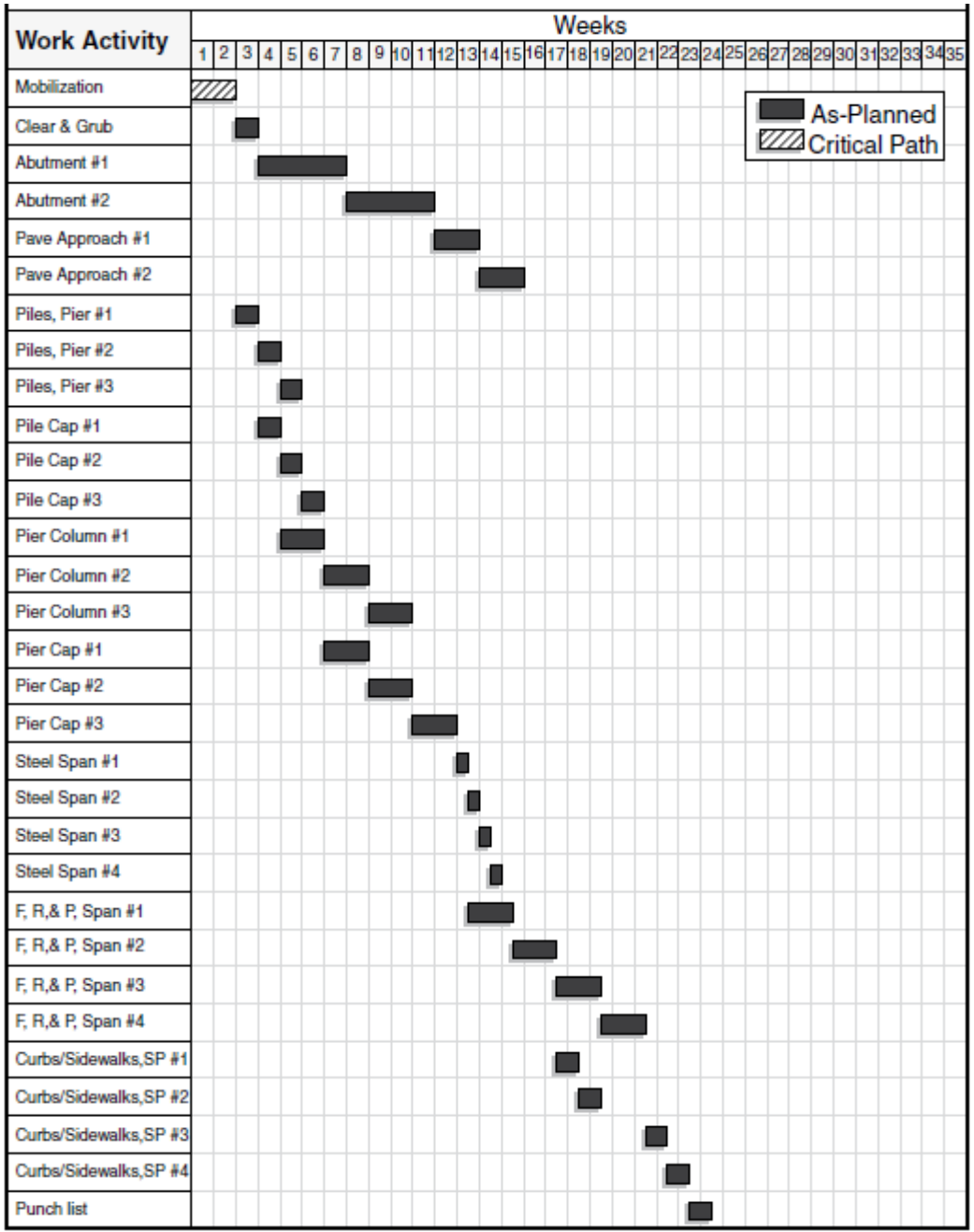
STEP 1: Identifying the critical path on a Gantt Chart – Example 1

- The **critical path starts** with the **mobilization activity** since **no other activity** is scheduled to **occur during this period**.
- The **next two activities** are:
  1. Clear and grub activity
  2. Piles at pier #1
- In **reviewing** the **sequence of activities**, the **clear and grub activity** is related to **abutment and approach work**.



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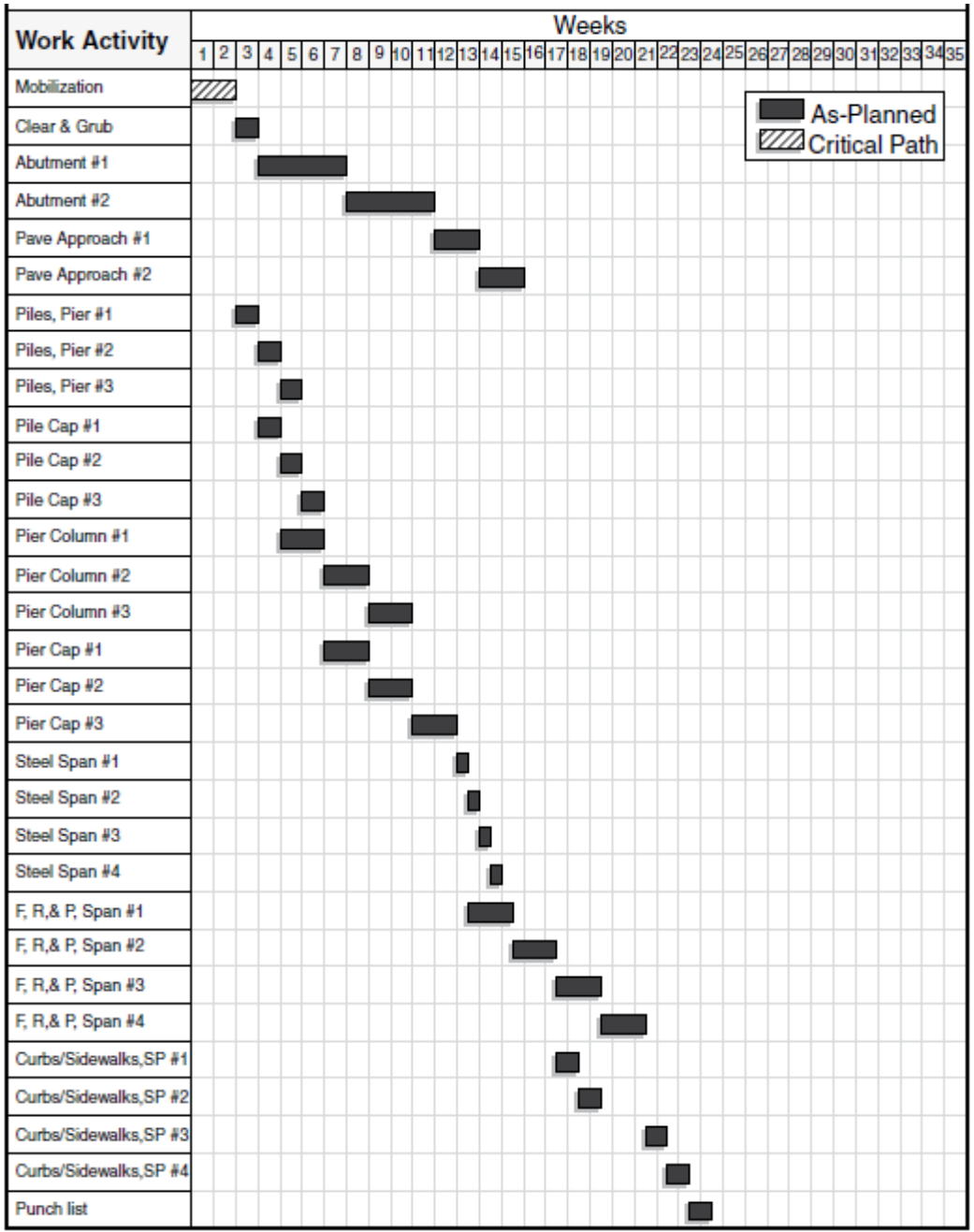
STEP 1: Identifying the critical path on a Gantt Chart – Example 1

- The **abutment and approach work** is scheduled to **finish** well **before the end of the Project** but **does not appear** to be **related** to the **schedule of activities** for **bridge construction**.
- Contract says the **"approaches"** are **not concrete**, therefore there is **no contractual or mandatory constraint** to **coordinate the placement** for the **bridge with the approaches**.



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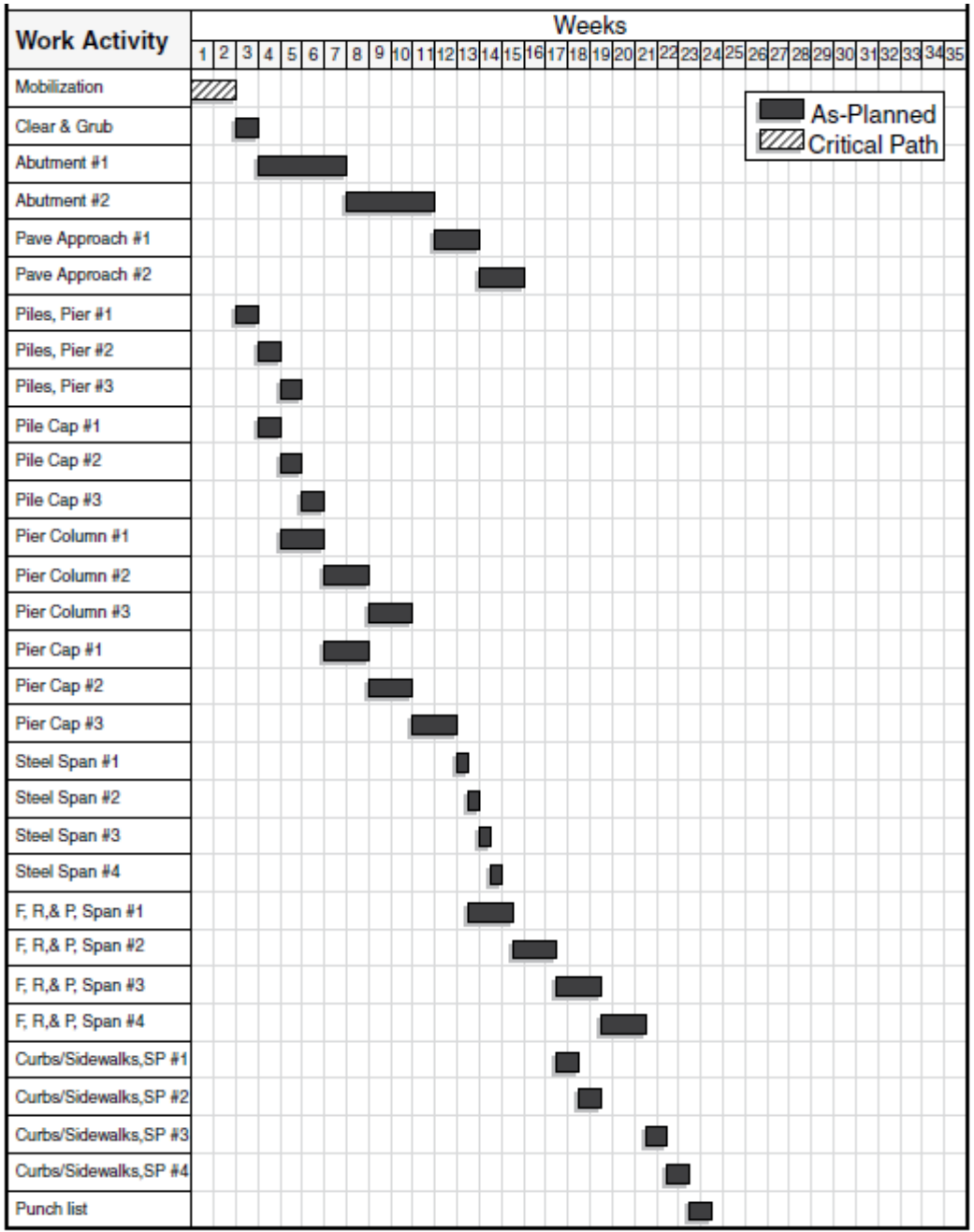
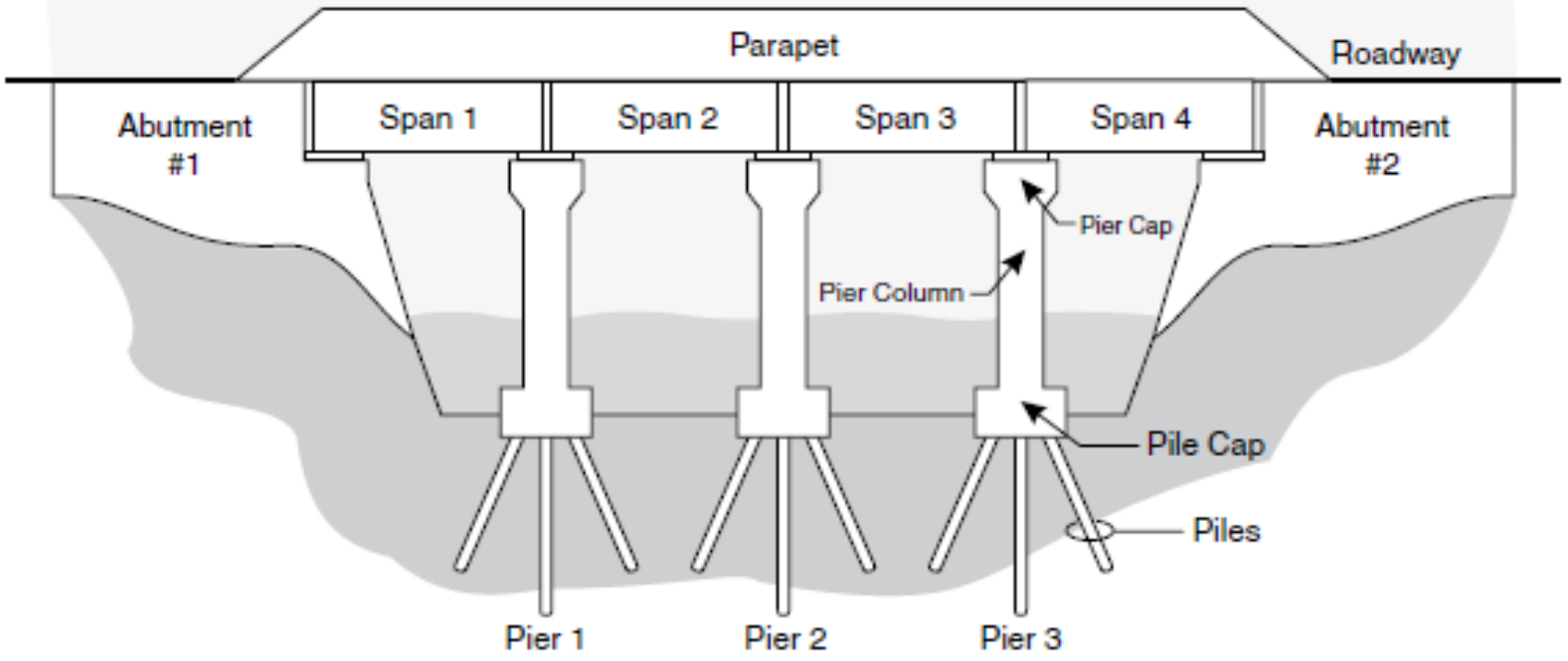
STEP 1: Identifying the critical path on a Gantt Chart – Example 1

Abutment and approach work are not on the critical path

Therefore, the critical path must be through the piles and piers.



STEP 1: Identifying the critical path on a Gantt Chart – Example 1



STEP 1: Identifying the critical path on a Gantt Chart – Example 1

RE: Bridge Project
Narrative Schedule

Dear Engineer,

The bridge construction project consists of two abutments (Abutment #1 and Abutment #2), three pile-supported piers (labeled Pier #1, Pier #2, and Pier #3 from west to east), and four spans with steel girders and concrete decking (labeled Span 1, Span 2, Span 3, and Span 4 from west to east).

I will mobilize to the site on April 1, 2008, and plan to construct this bridge by moving from west to east. I plan to construct the bridge abutments and piers concurrently. One crew will construct Abutment #1 and then Abutment #2 and at the same time Piers #1 through #3 will be constructed starting at Pier #1 through Pier #3. The construction of the spans will follow the installation of the piers.

I expect the construction of each abutment to take approximately 6 weeks and the construction of each pier to take approximately 8 weeks. I expect that all of the abutments and piers will be in place and ready to accept the steel girders for the spans by the end of July.

From the end of July until the middle of October, I plan to erect the steel for the four spans, form and pour the decks, and form and pour the parapets and sidewalks. After completing any punchlist work, I plan to open the bridge to traffic on October 20, 2008.

Please feel free to contact me with any questions.

Sincerely,
Bob Smith
Project Manager

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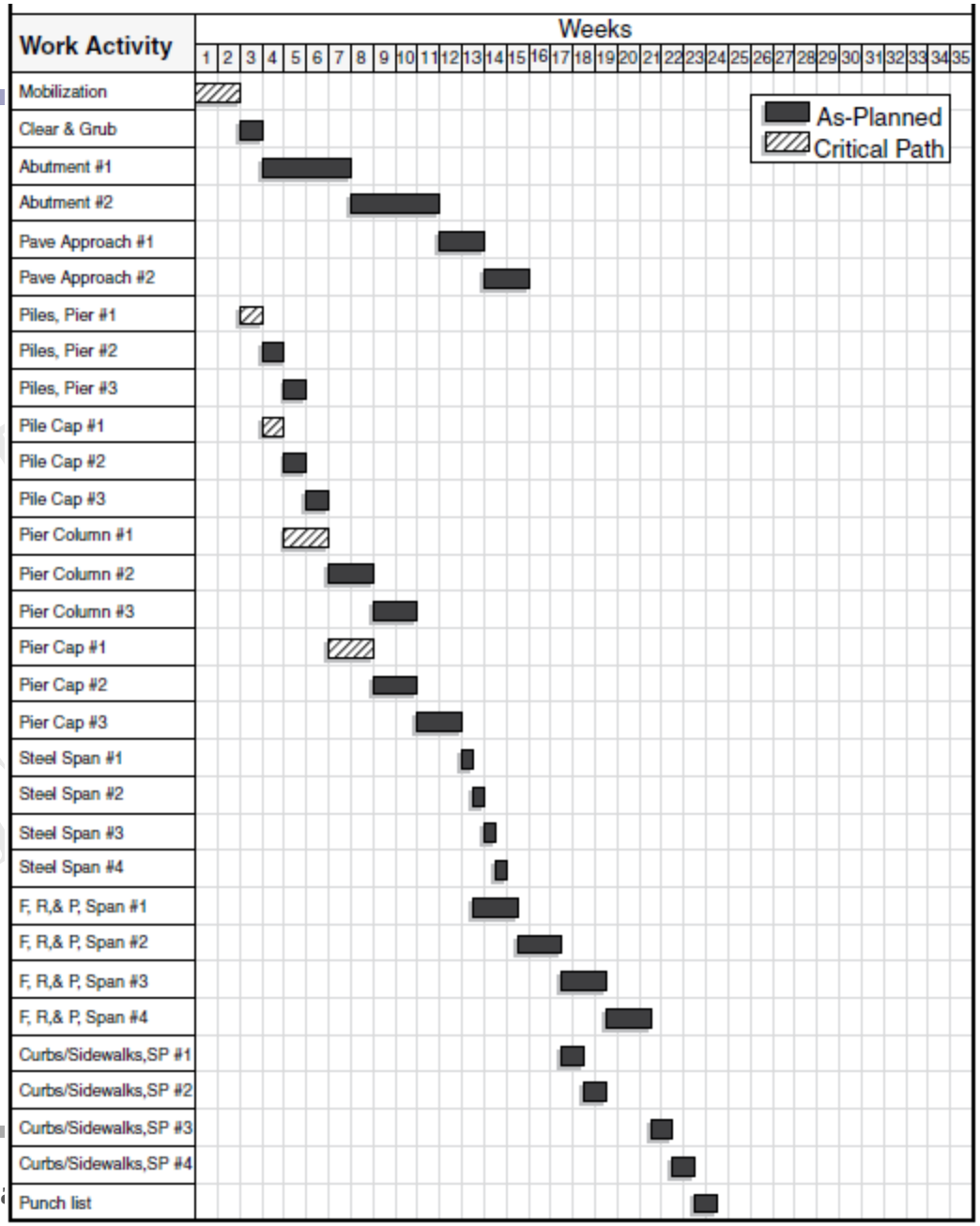
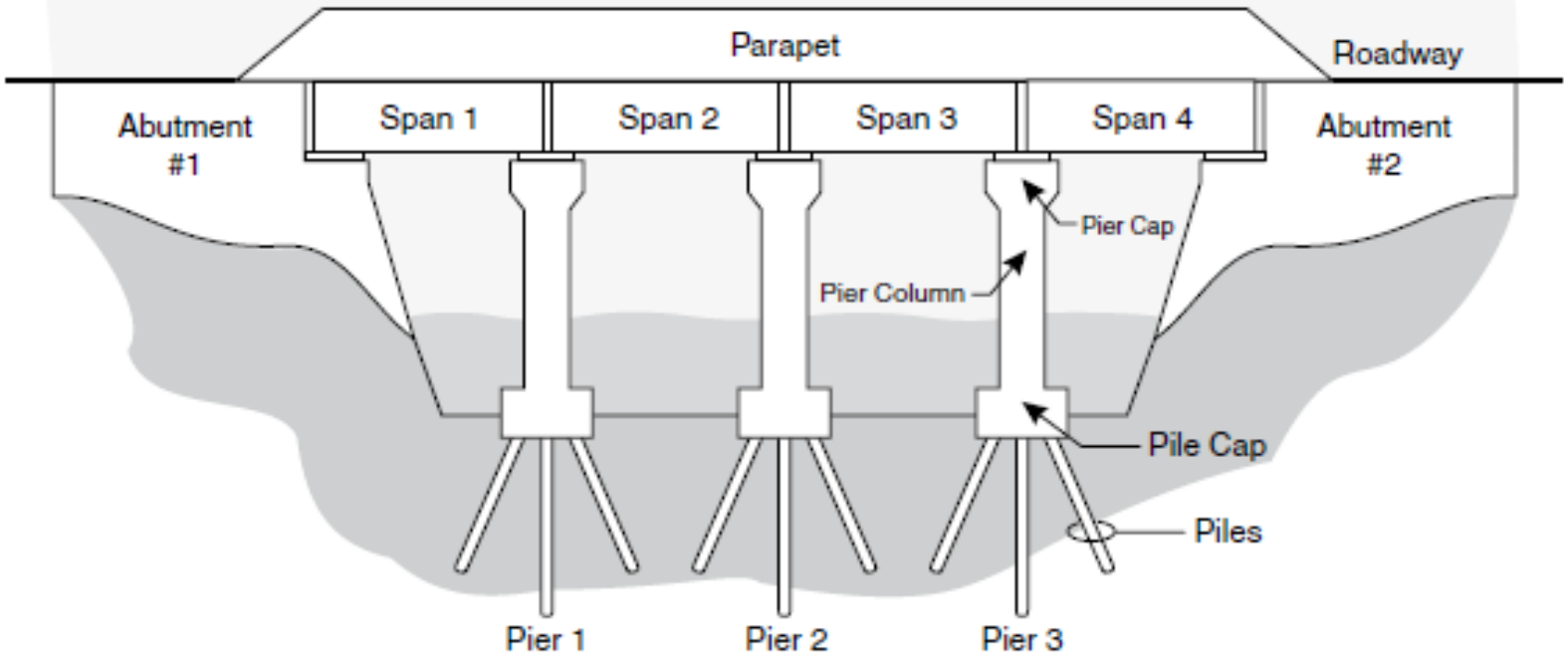
STEP 1: Identifying the critical path on a Gantt Chart – Example 1

- The **critical path** must **move through** the **piles and piers**.
- When **viewing** this **Gantt chart**, the analyst sees that the work is **"stair-stepped"** through the specific activities for **each pier**.
  - Thus, the **piles at pier #1** are **complete** and the **piles at pier #2** are **starting**.
- **Critical path appears to follow:**

  ==> Piles—Pier #1
  ==> Pile Cap #1
  ==> Pier Column #1
  ==> Pier Cap #1



STEP 1: Identifying the critical path on a Gantt Chart – Example 1



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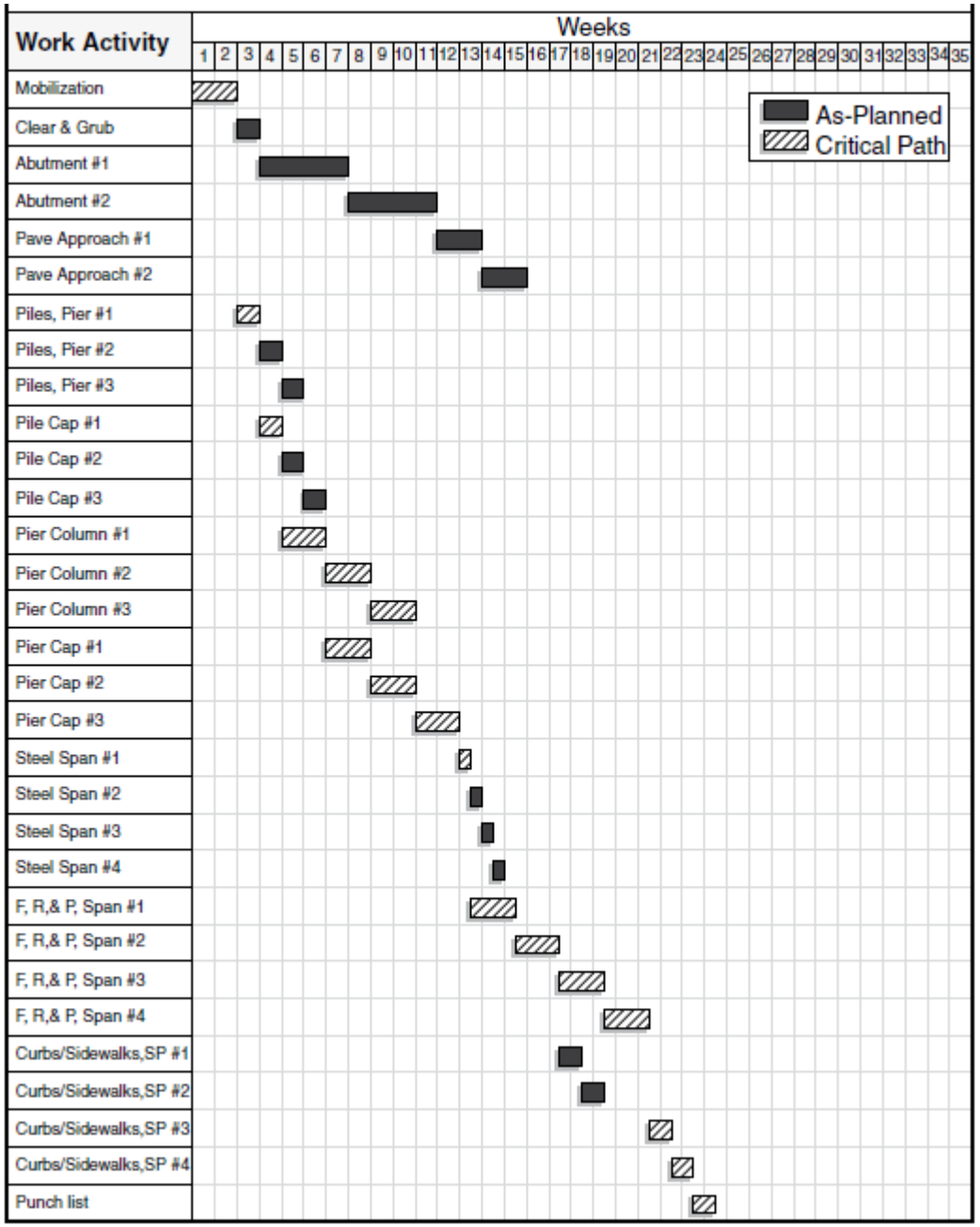
STEP 1: Identifying the critical path on a Gantt Chart – Example 1

- **Pier column #1** can be started when **Pile cap #1** is finished.
- **Steel span #1** can be **started when only all pier columns** and **caps completed**.
- **Span deck #2** can **only** be started when **span deck #1** is **finished**.
- **Punch list** can **be started** when **only all sidewalks** are **finished**.



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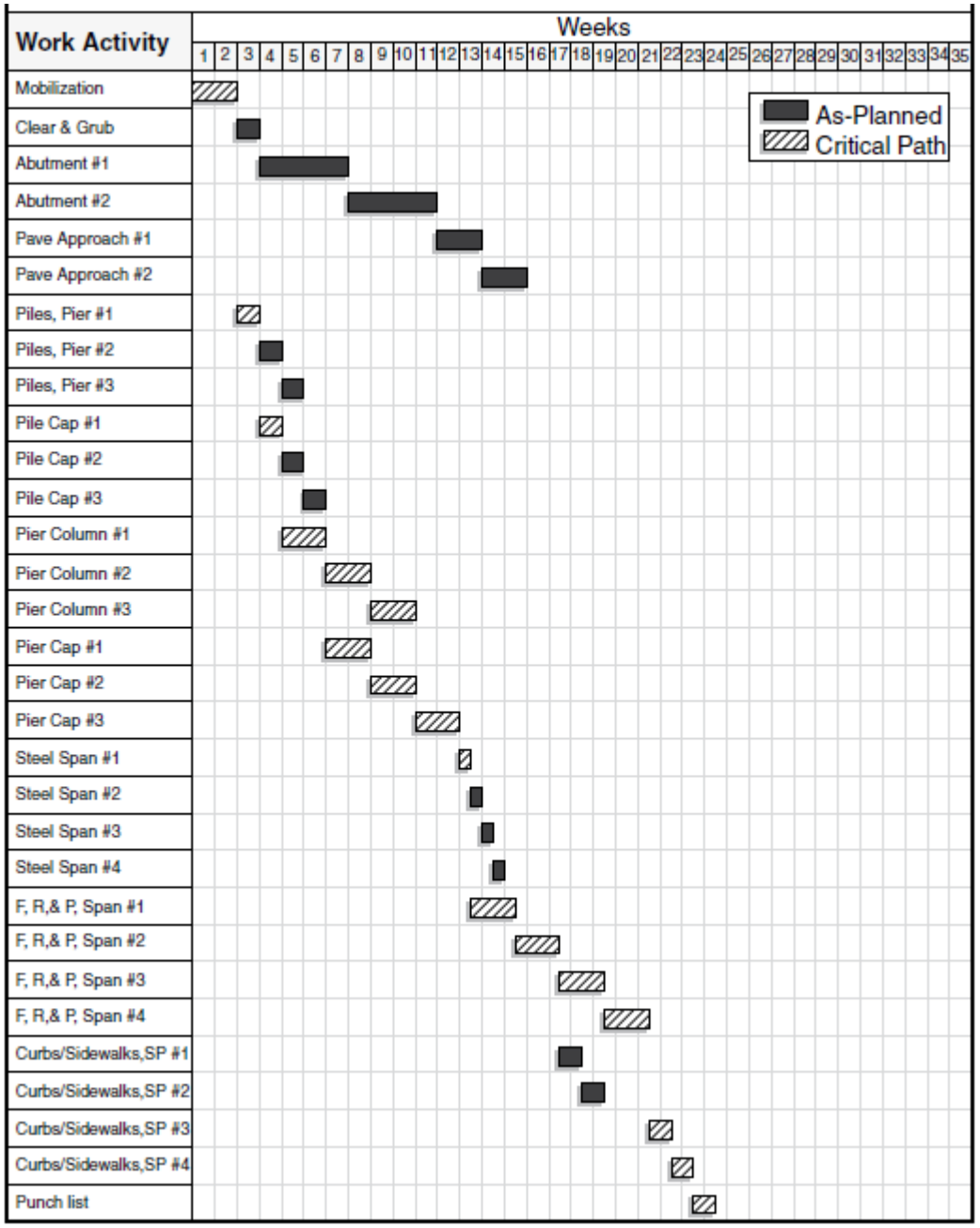
STEP 1: Identifying the critical path on a Gantt Chart – Example 1

- **The overall critical path is:**
  - ==> Mobilization
  - ==> Piles—Pier #1
  - ==> Pile Cap #1
  - ==> Pier Column #1
  - ==> Pier Column #2
  - ==> Pier Cap #1
  - ==> Pier Column #3
  - ==> Pier Cap #2
  - ==> Pier Cap #3
  - ==> Steel Span #1
  - ==> F, R, & P Span #1
  - ==> F, R, & P Span #2
  - ==> F, R, & P Span #3
  - ==> F, R, & P Span #4
  - ==> Curbs & Sidewalks Span #3
  - ==> Curbs & Sidewalks Span #4
  - ==> Punch list



STEP 2: Quantifying delays using Gantt Chart schedule

- The **process of quantifying** the delays using a **Gantt chart** is **similar** to the process when a **CPM schedule is available**.

- To **start the process**, the analyst **must prepare** a **detailed as-built diagram** that shows as specifically as possible when the **work was actually performed**.

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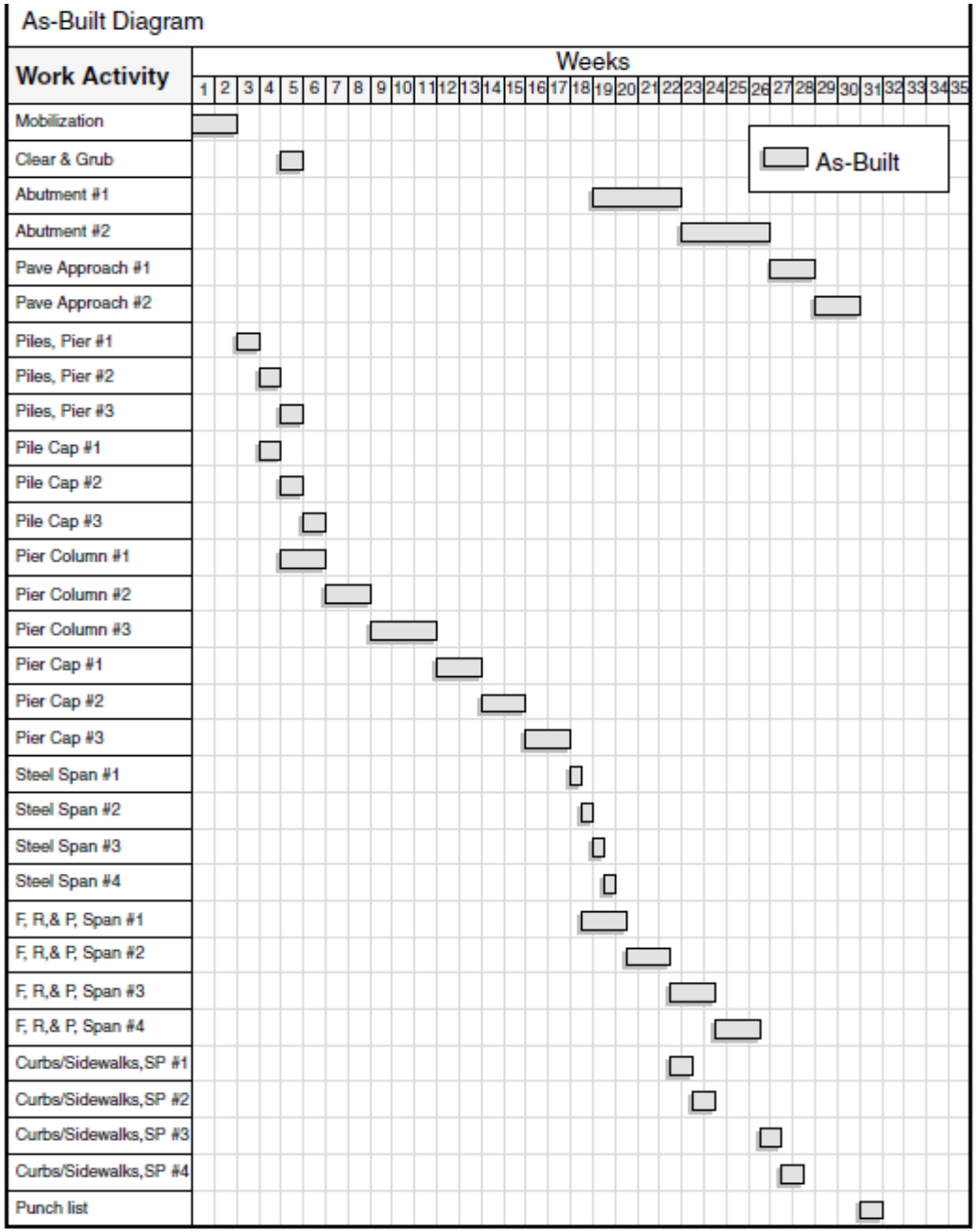
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

Project should have been completed during week 24, whereas it takes 31 weeks

- **Mobilization** is on time.
- **Remaining activities did not** processed **similar** to **as-planned schedule.**
- Let's look at the **first three delays** to **demonstrate** the **delay analysis methodology** that can be applied to the **rest of the project**.



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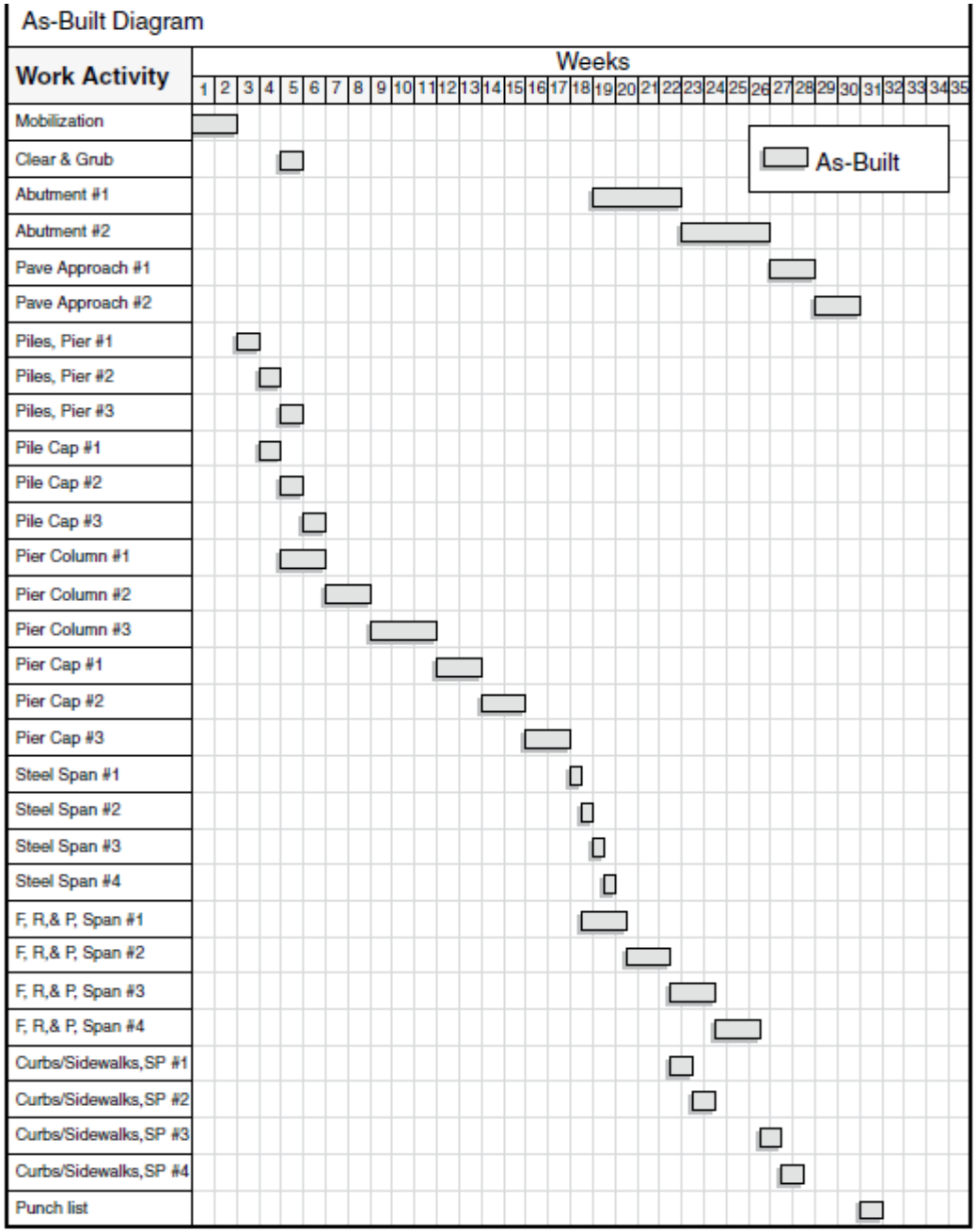
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

- At the end of 5th week.
- As the **as-built diagram** shows, the pile driving at
  1. **Piers #1, #2, and #3**;
  2. **Pile caps at piers #1 and #2**;
  3. **Pier column #1**

were accomplished **as-planned** in the three weeks immediately following the **mobilization activity**.



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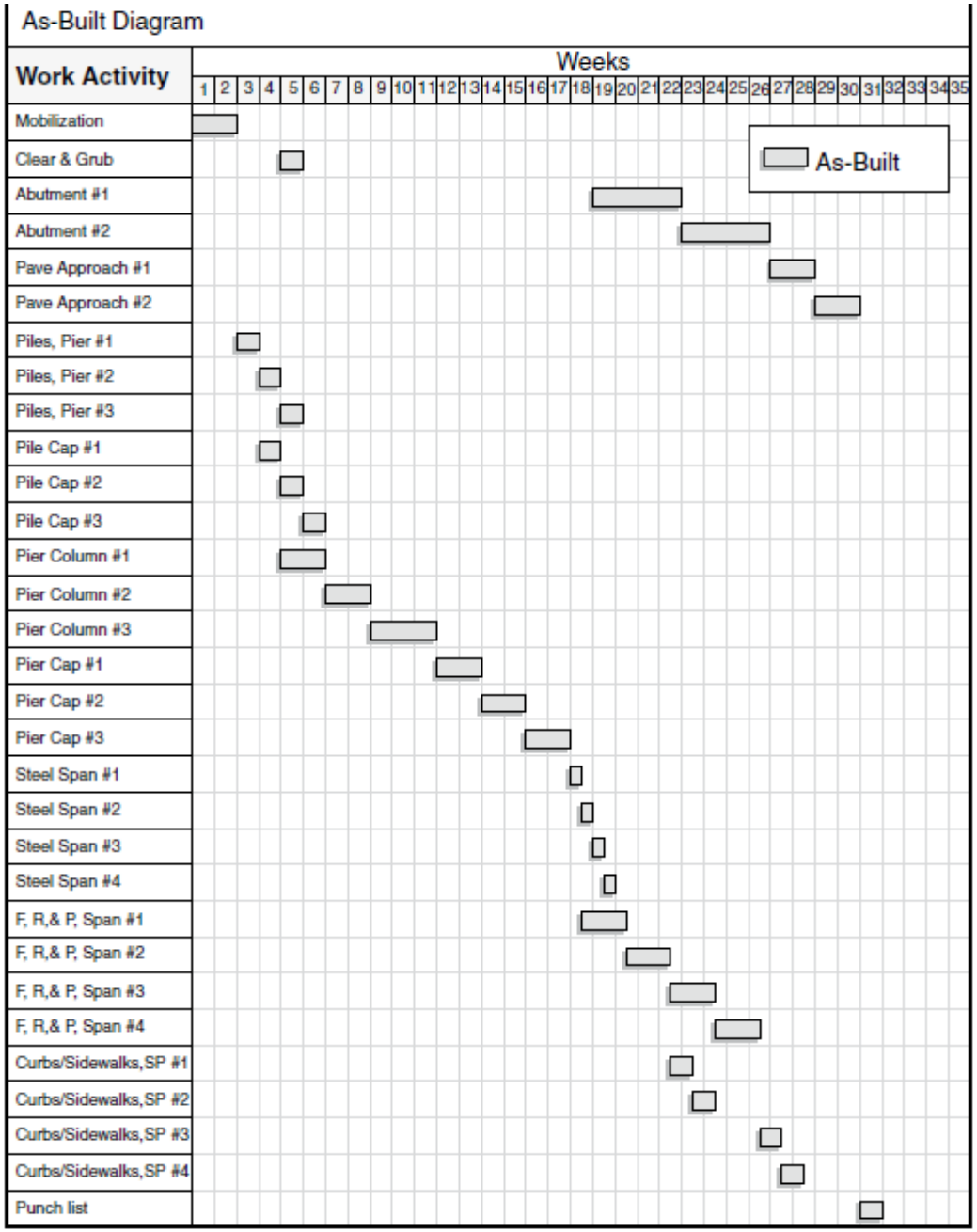
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

- At the end of 5th week.
- The **clear and grub activity**, however, did **not proceed as planned** but started **two weeks** late and **finished in a duration** of one week (**the planned duration**).
  - If the **previous conclusions concerning the critical path were correct**, the delay to the start of **clearing and grubbing** should **not have resulted** in a **delay to the Project**.



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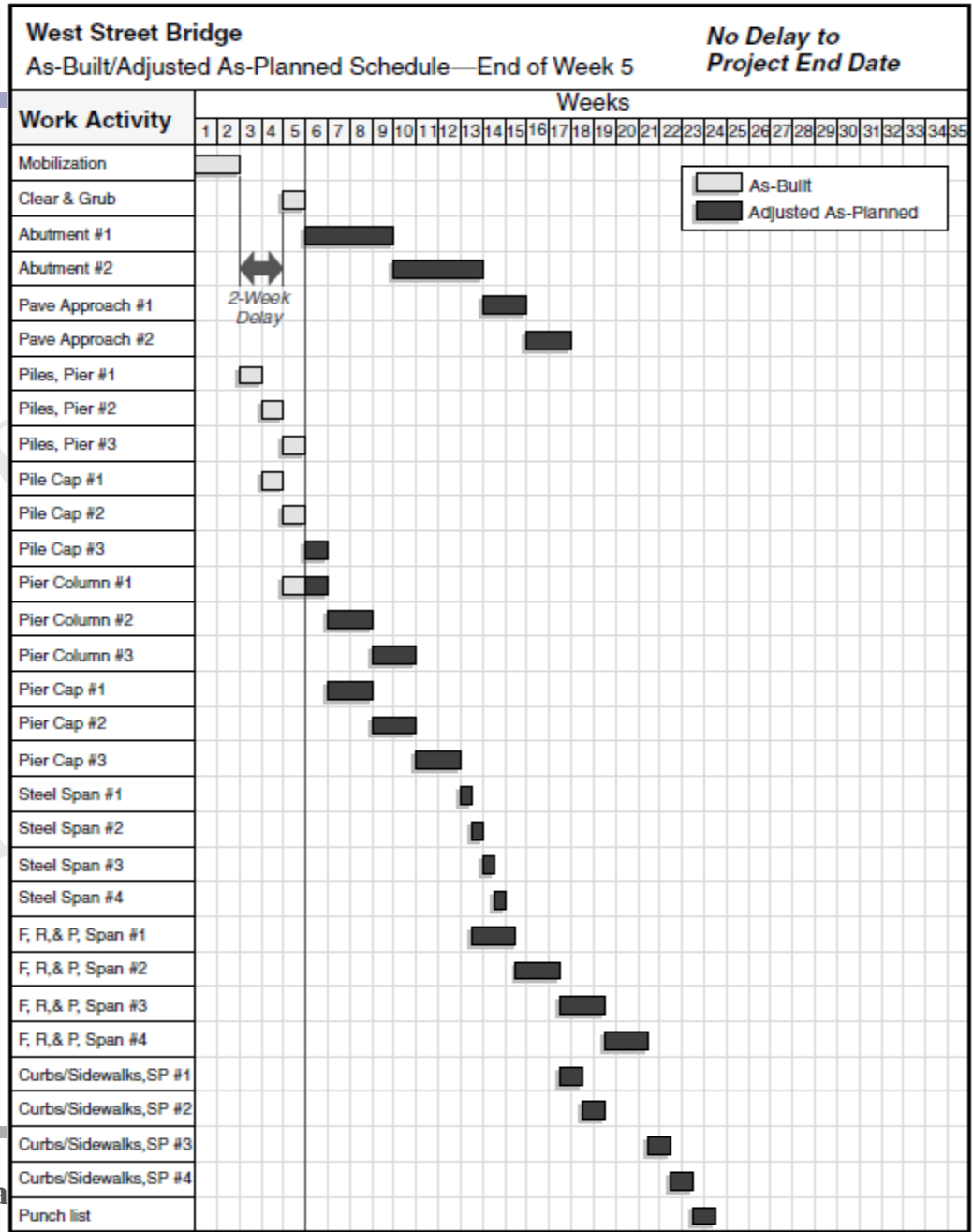
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

- At the end of 5th week.
- To check the **conclusion in previous slide**, the **analyst** can **"update"** the **Gantt chart** as of the **end of week five**, as shown in this figure.

The abutment and approach work has been delayed in time, however there is no delay to the critical path and the Project is still on schedule.



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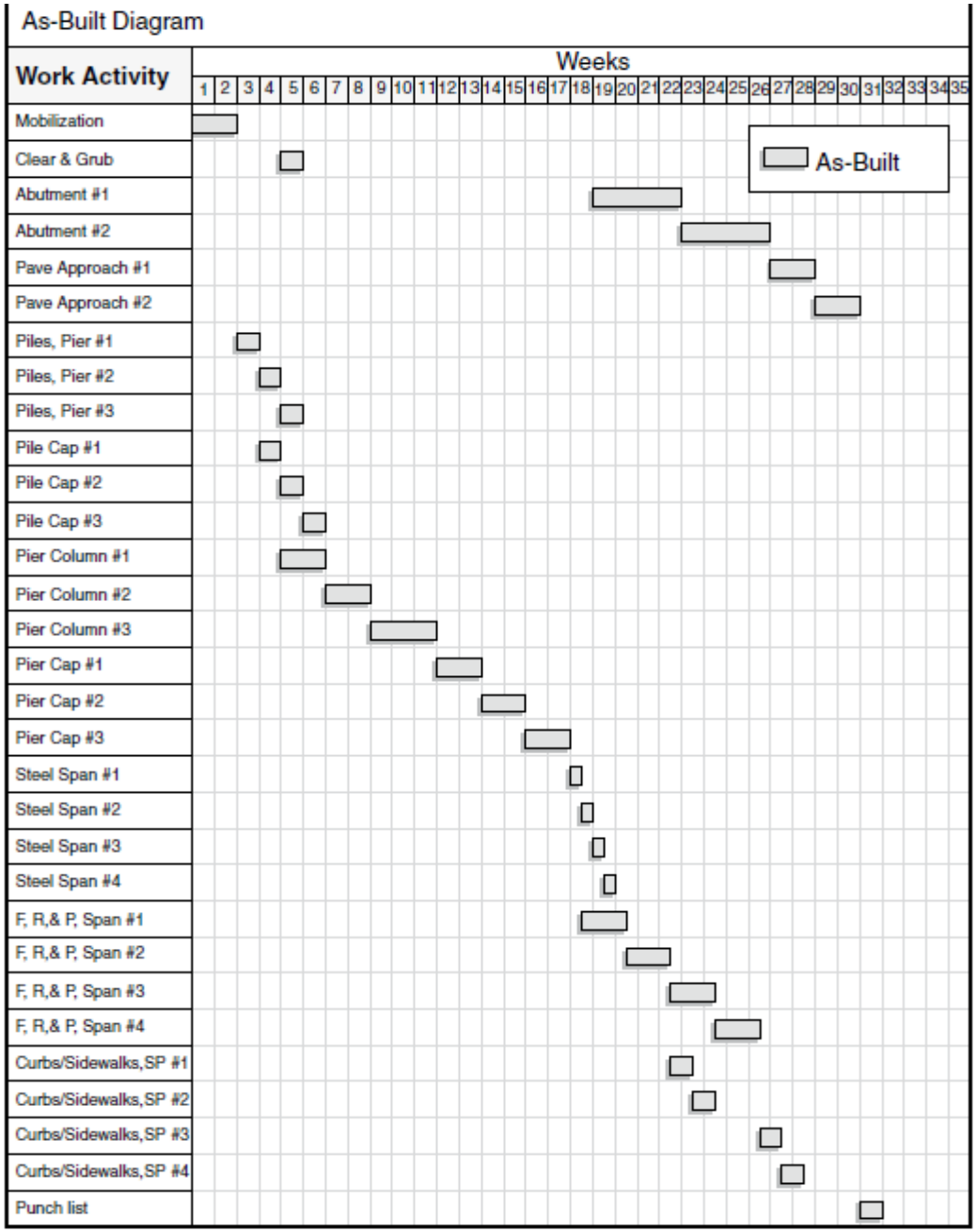
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

- The analyst decides to "update" the schedule as of the end of **week 11.**
- The **abutment/approach work** has **not yet begun.**
- The **pier cap work** also has **not yet begun**.
- **Pier columns #1 and #2** were completed **on schedule**.
- **Pier column #3**, however, took **one week longer** to complete than planned.



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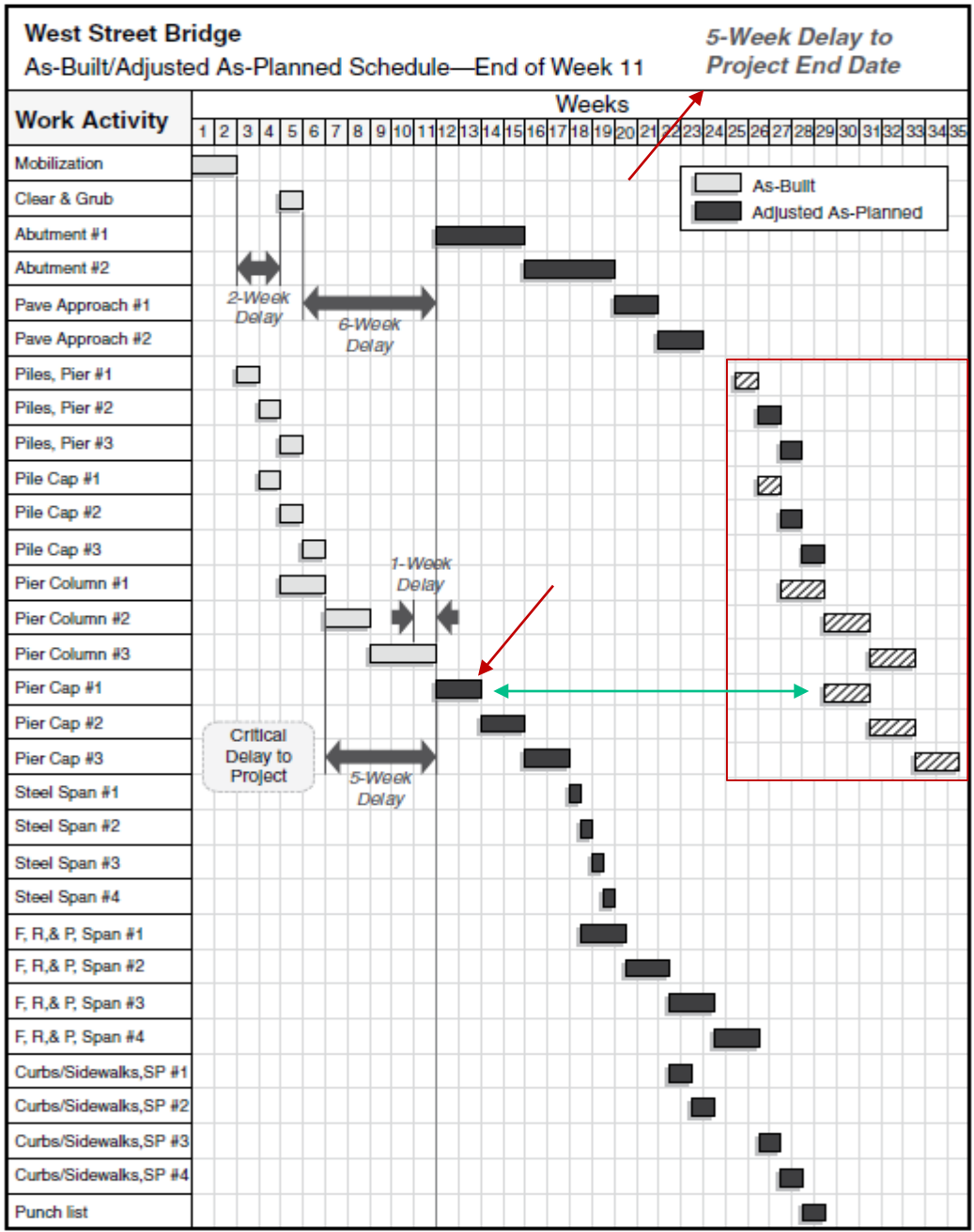
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

- Project is now **five weeks behind**.
- The delay was caused by the **late start of pier cap #1 work**.
- Although **pier column #3** was **late** in finishing and was **on the original critical path**, once the **pier cap #1** activity did **not start on time**, the **critical path shifted** to **depend solely** on the **pier cap work**.
- The **pier column #3 activity** was effectively **given float** by virtue of the **delay to the pier cap activity**.



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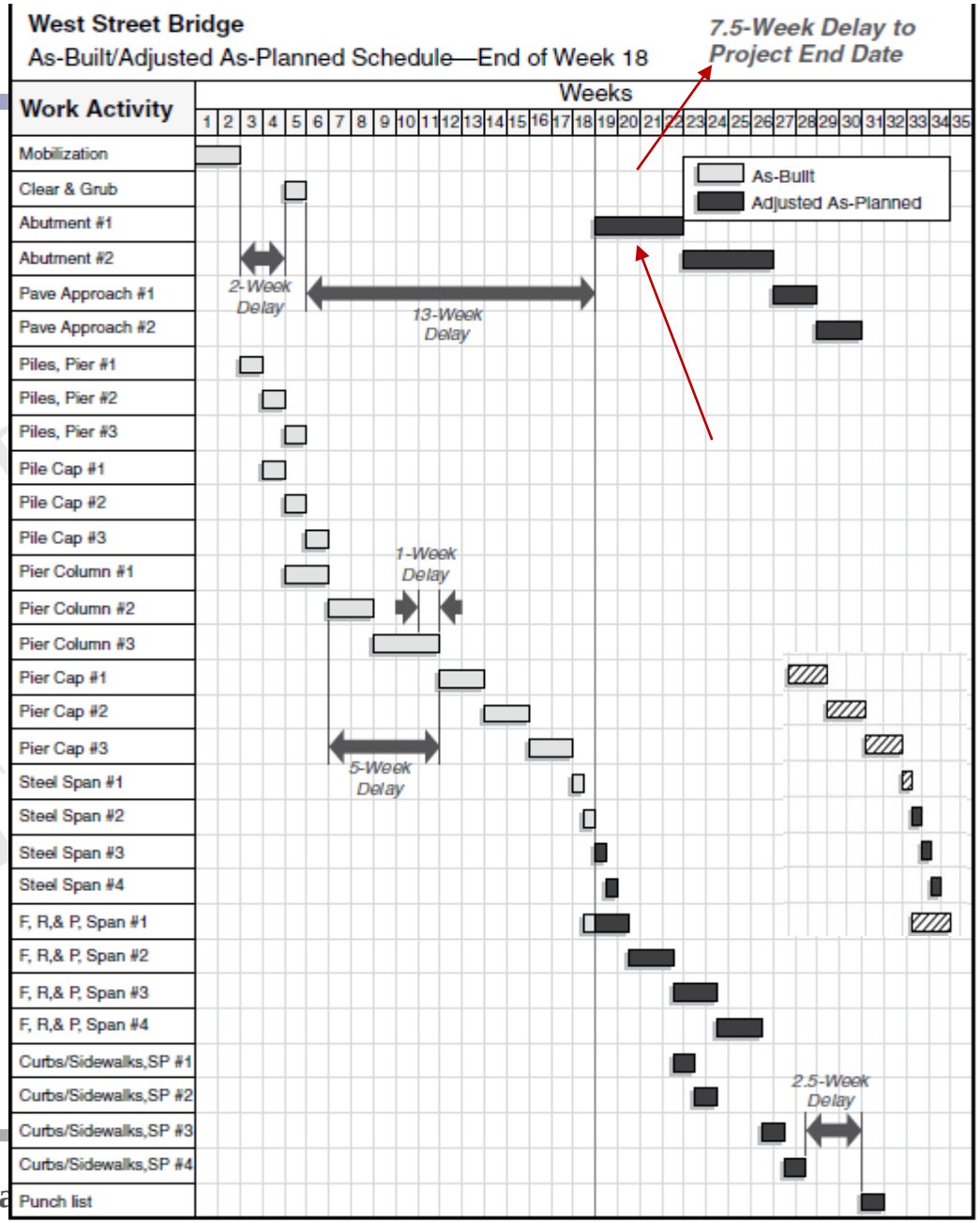
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1

- Next, the **analyst** decides to **"update" the schedule** at the end of **week 18**.
  - This **point is chosen because** the **critical path shifts**.
- The **additional two and one-half weeks delay** appears to be the result of a **lack of progress** on the **abutment/approach path**.



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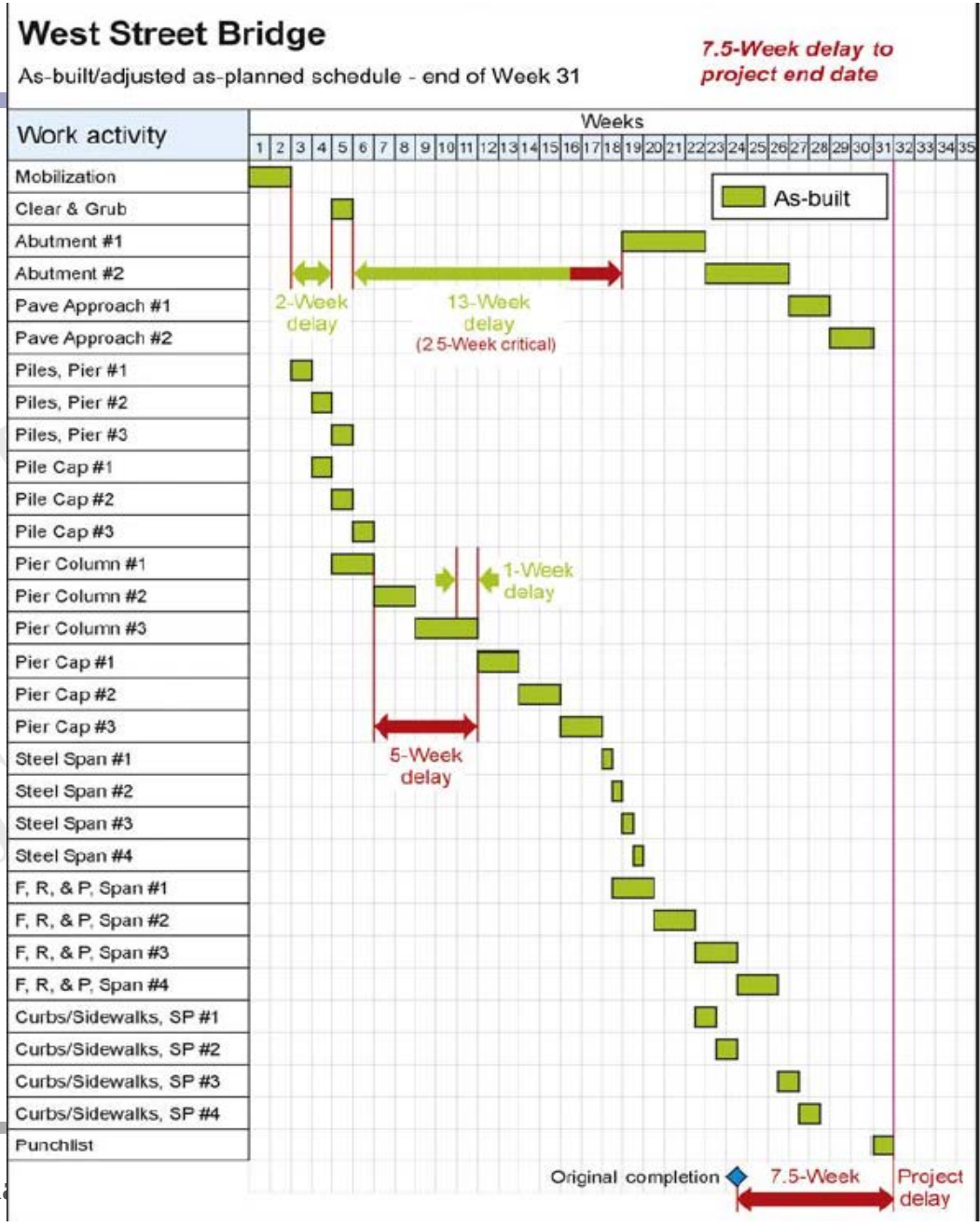
STEP 2: Quantifying delays using Gantt Chart schedule – Example 1



STEP 2: Quantifying delays using Gantt Chart schedule

BUT

We did not follow the process…

Why?

Because changes should have been added to the Gantt Chart as they occurred

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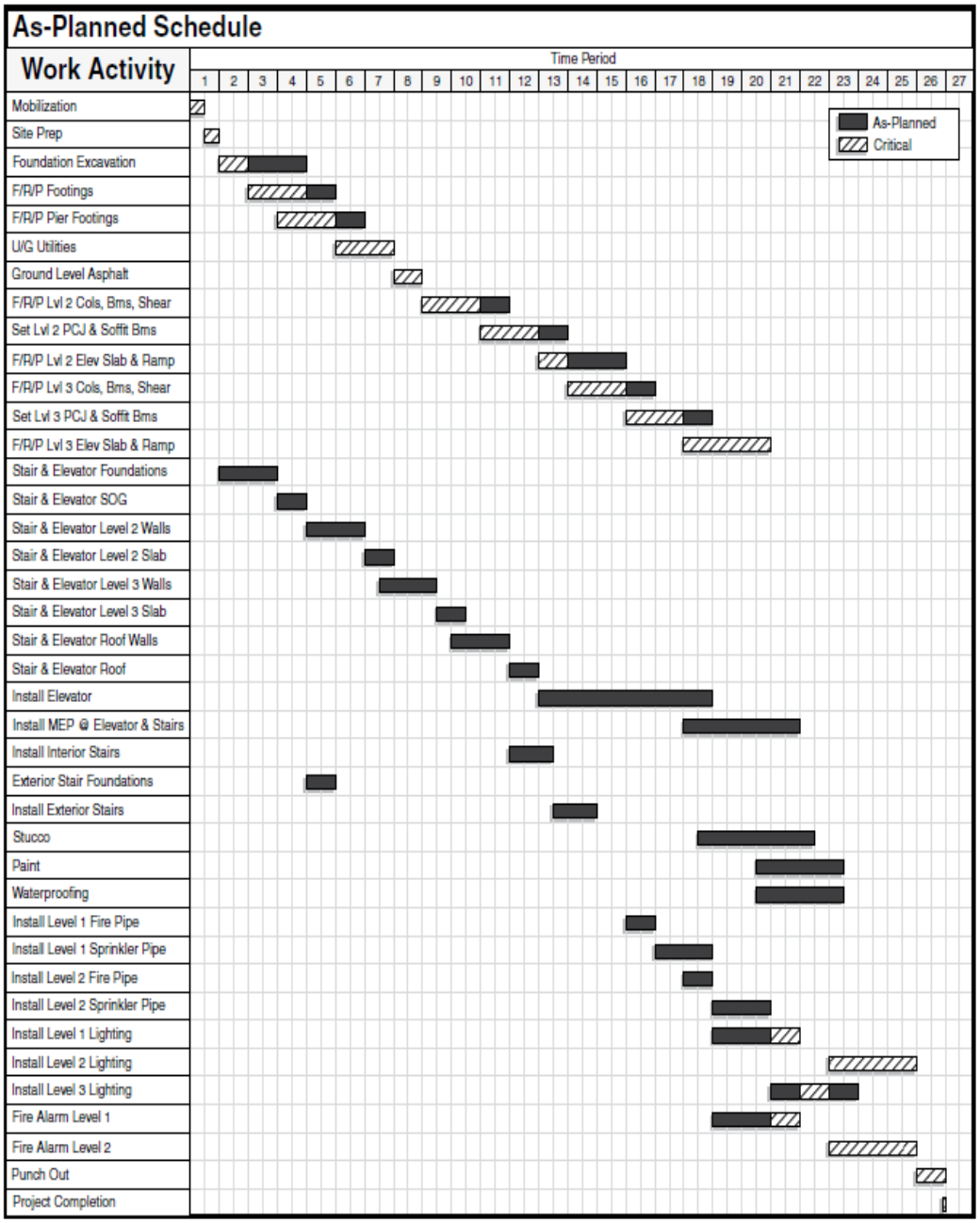
STEP 1: Identifying the critical path on a Gantt Chart – Example 2

AS-PLANNED SCHEDULE

- To **further illustrate** the process of determining delays with a **Gantt chart**, the following example of the construction of a **simple, three-story building** will be used.
- Based on a **review** of the schedule, the **critical path** has been shown with **cross-hatched bars**.



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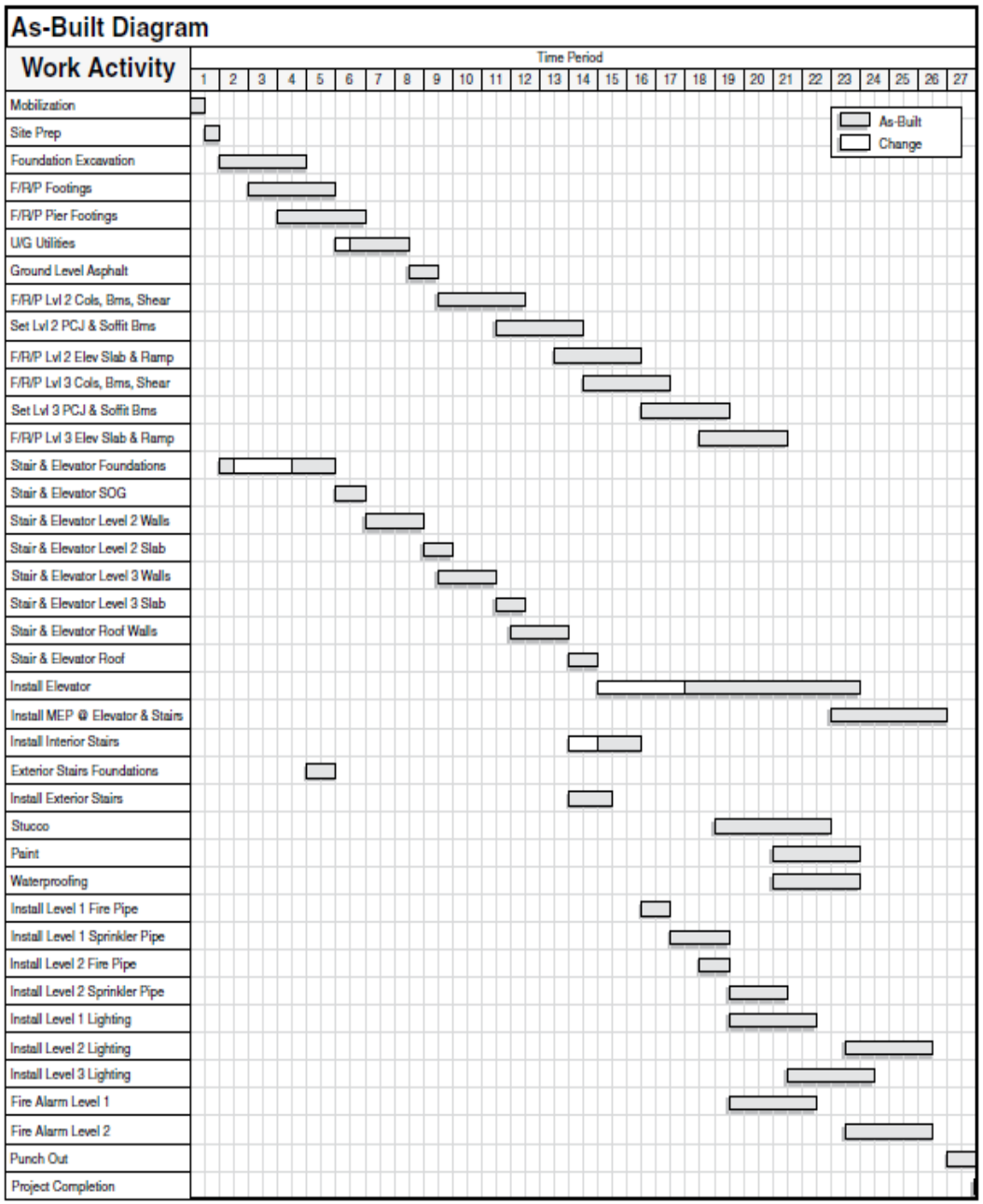
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

AS-BUILT SCHEDULE

- **During the course of the Project**, there were **four changes** that occurred that **might have affected** the **Project completion date**.
- The **as-built diagram** with the changed work highlighted in white is shown in the figure.



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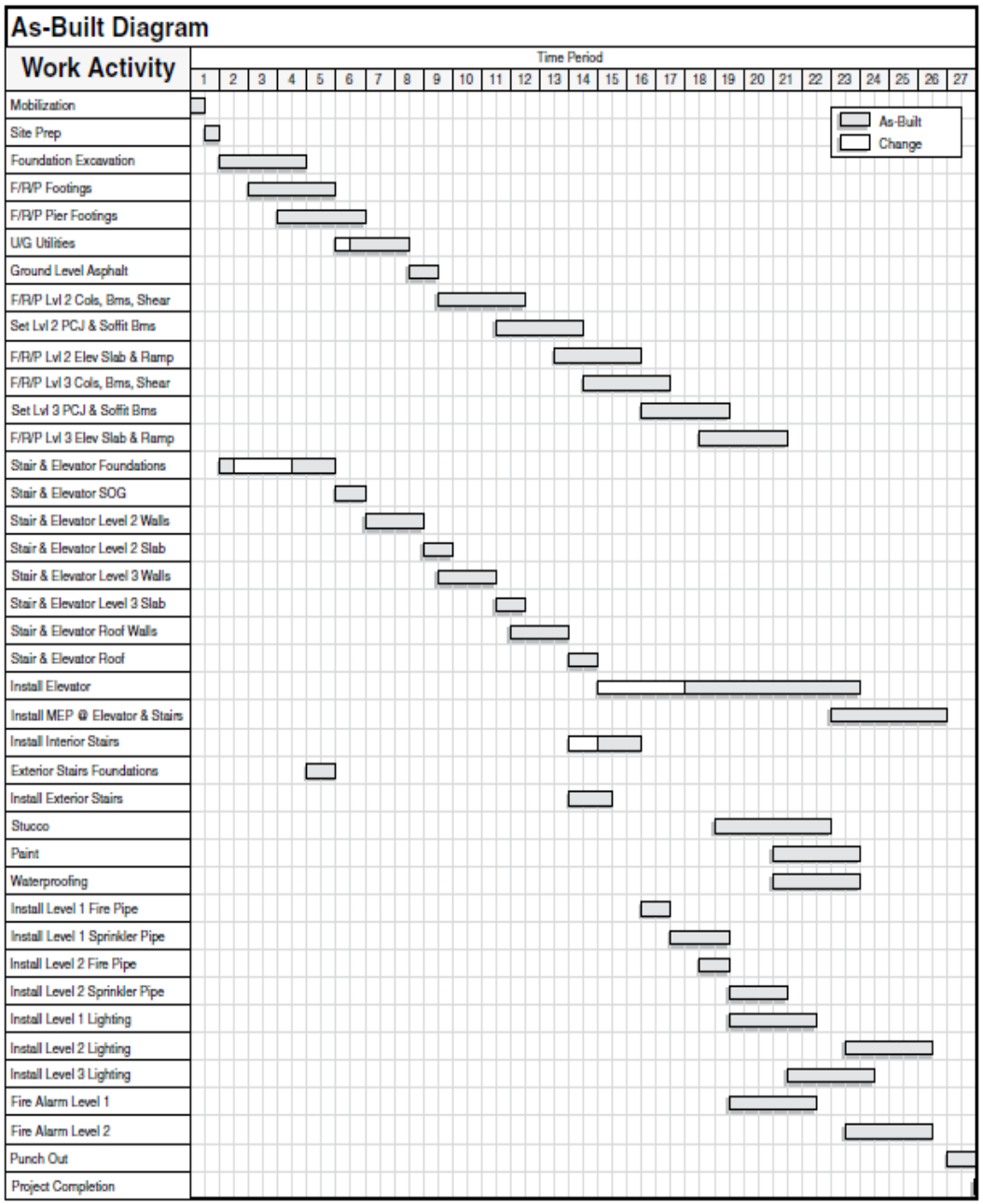
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

AS-BUILT SCHEDULE

- You should be aware that you **cannot only look** at a **comparison** of the **as-planned schedule** and the **as-built diagram** and **draw conclusion**.
- **Instead**, the analysis **must apply** the **changes** as they **occur** and **measure** any **delay**, as it would **have occurred**.



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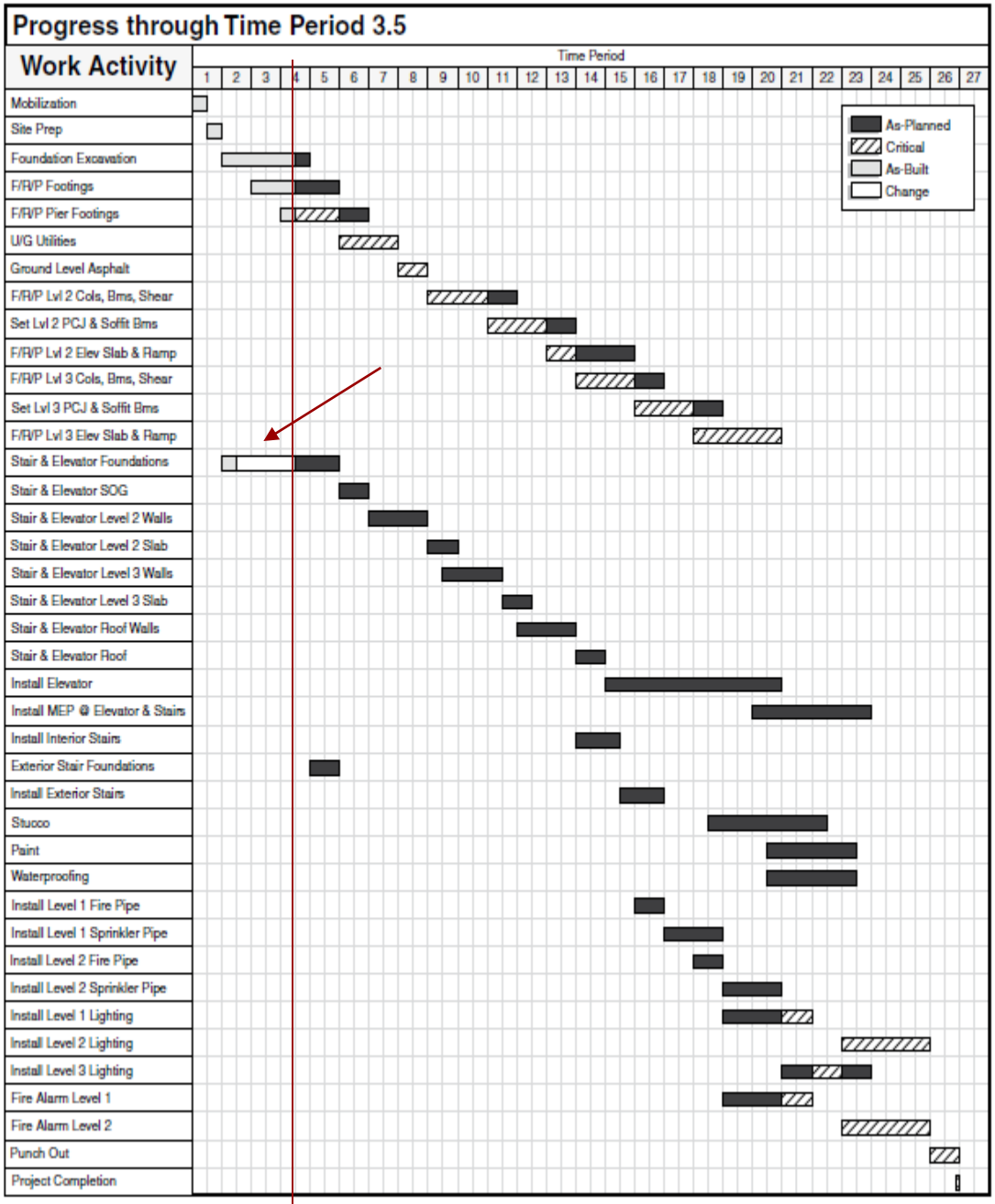
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

- **Analyst** could be performing the analysis **contemporaneously** as the **Project progresses**.
- In this case, the **as-built diagram** would be **prepared up to the date** of the **change** and **any delays determined at that time**.
- The figure shows the project as of **time period 3.5**.



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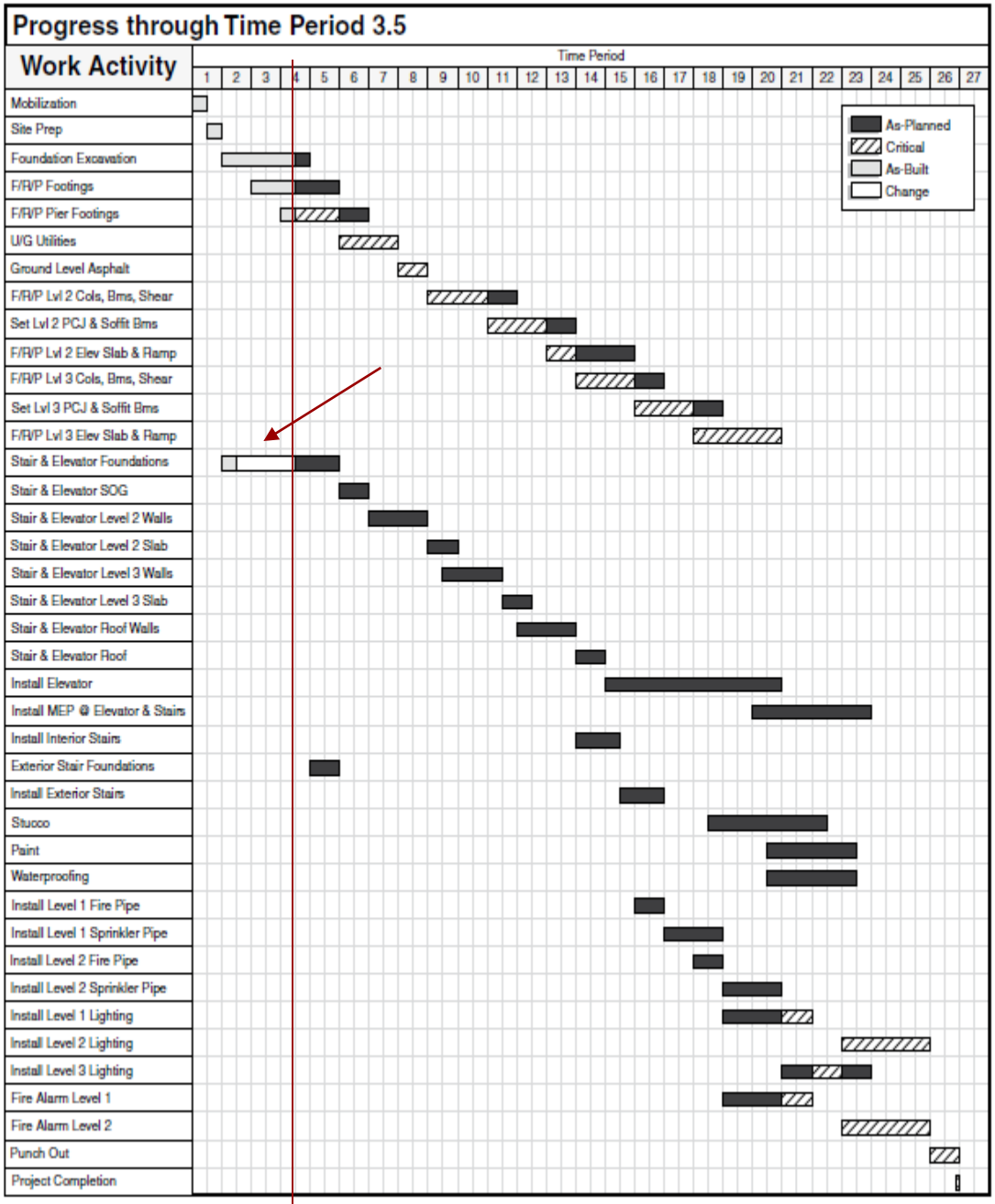
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

- **Comparing as-planned schedule** and **updated schedule** in time **period of 3.5**, the project is still **on time** and will be finished at the end of **time period 26**.
- **No delay** was **caused** by the **first change**.



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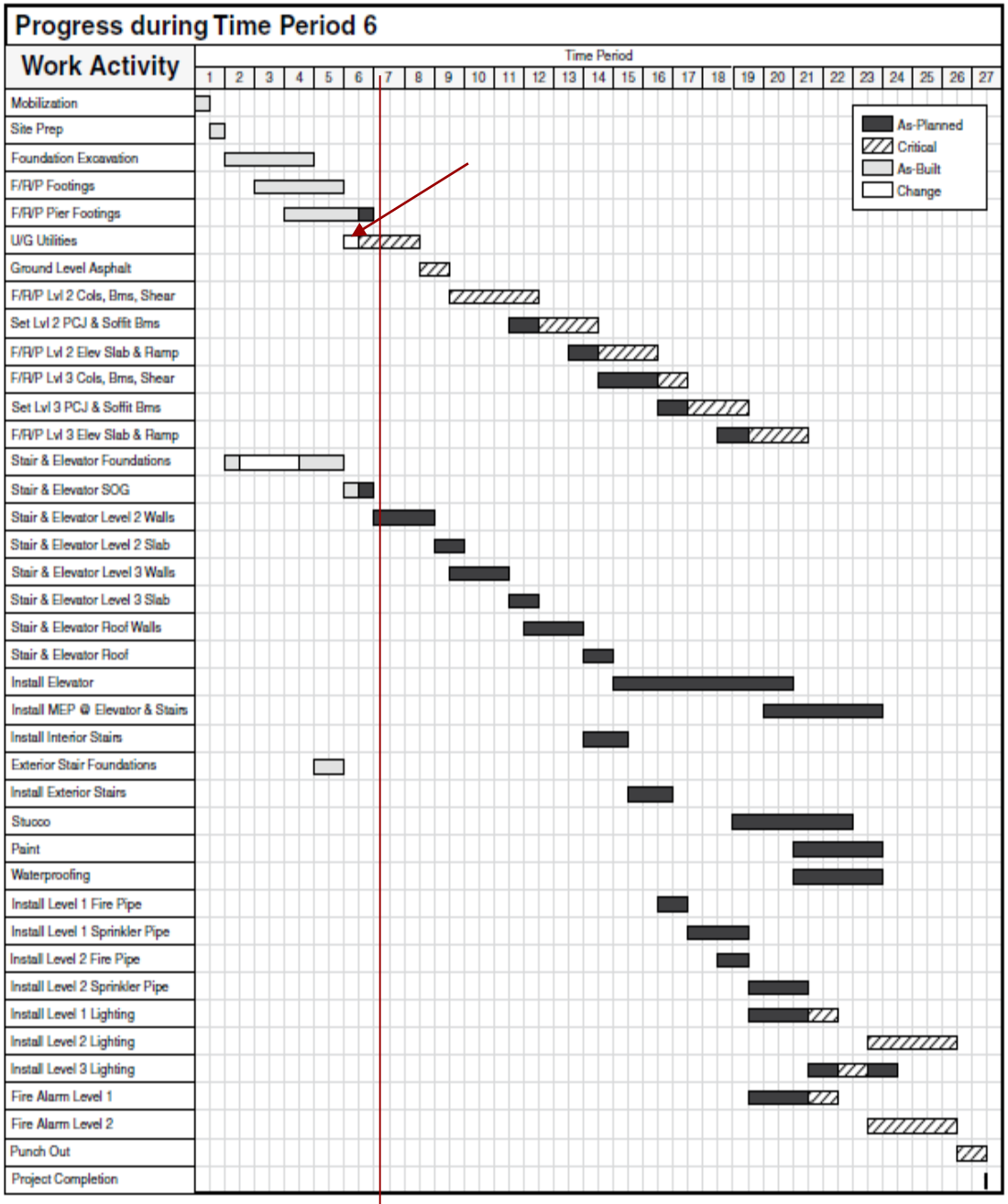
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

- The **next change** to the Project occurs during **time period 6**.
- **Comparing** the first update (**previous figure**) and the present update (**this figure**) of the schedule, the Project has been **delayed one-half time period** and will now finish in the **middle of time period 27**.
- **Change #2** affected the **critical work of the underground utilities**. So a **delay** has occurred **because of change #2.**



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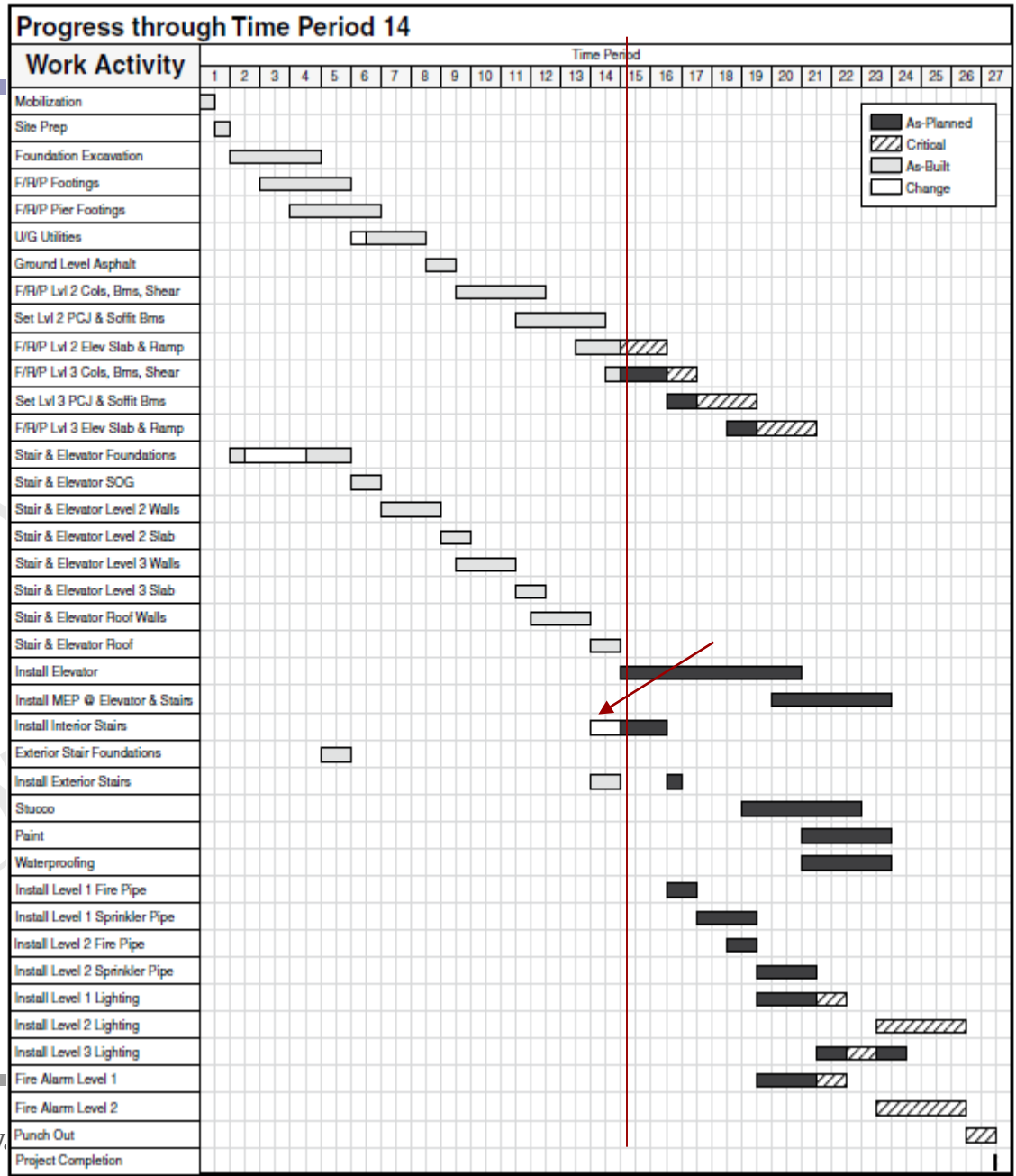
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

- The **next change** to the Project, **change #3**, occurred during **time period 14**.
- **Comparing** the **preceding update** and **this update**, the **end date** of the Project has **not changed**; therefore, the changed work **did not affect** the **critical path**, and **no delay resulted**.



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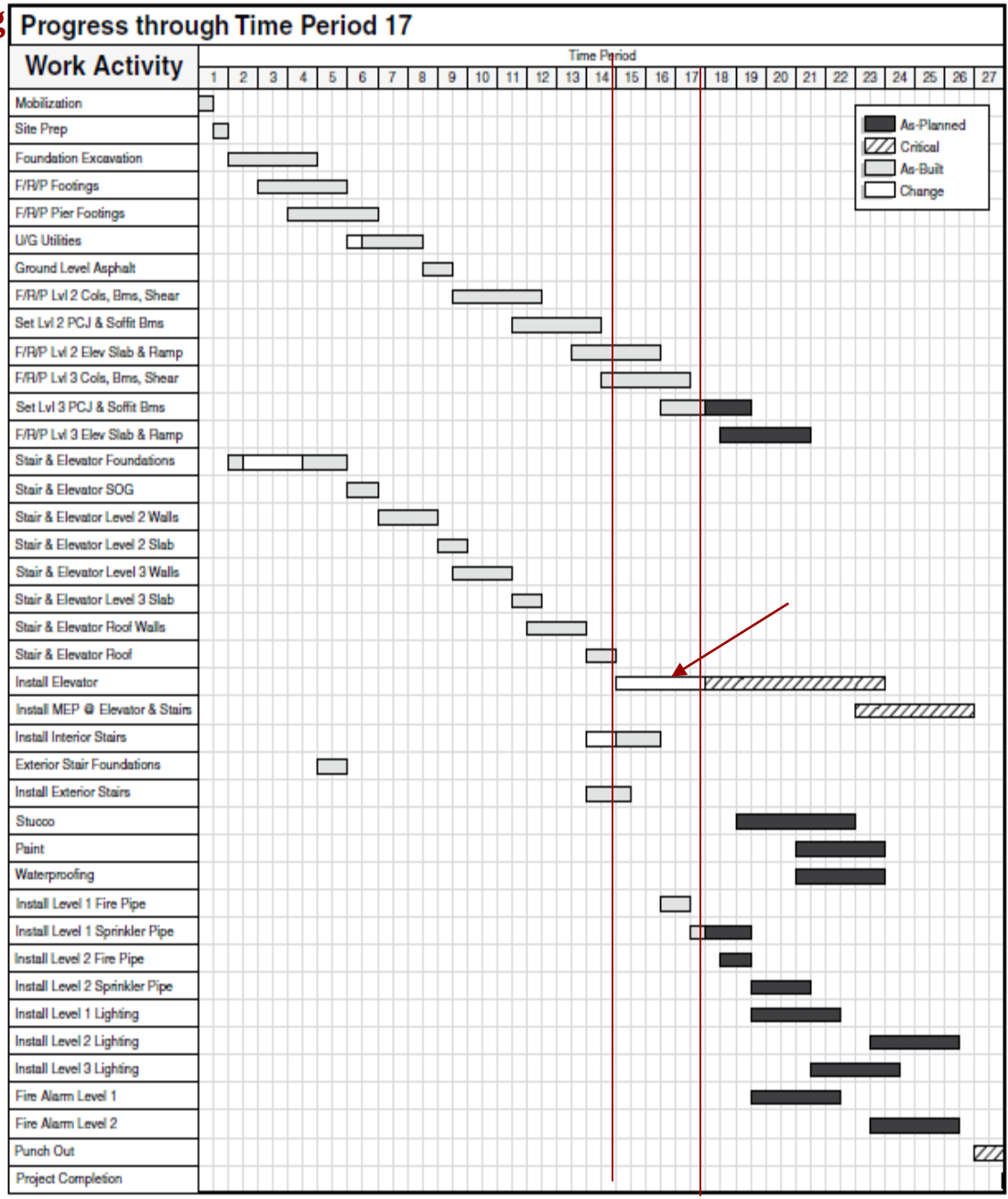
STEP 2: Quantifying delays using Gantt Chart schedule – Example 2

- The next change, **change #4**, occurred during **time periods 15 through 17**.
- The Project will now complete at the **end of time period 27** and has been **delayed half a time period**.
- Note that the **critical path** has **changed**. Because of the duration of the **changed work**, a **path** that previously **had float** is **now** the **critical path** and **caused** the **delay** that was measured.



STEP 2: Quantifying delays using Gantt Chart schedule

This section demonstrated how one can update a Gantt chart and determine delays contemporaneously while the project progresses and also identify changes in the critical path.

فرآیند جامع آنالیز تاخیرات در پروژه

بخش هفتم:
آنالیز زمانی تاخیرات

آنالیز زمانی تاخیرات قبل از وقوع تاخیر
(Contemporaneous Schedule Analysis)

ارائه دهنده:

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What we will learn?

- Critical path techniques
  - Delay analysis key terms – Review
  - Delay analysis using prospective methods
    - ✓ Impacted as planned analysis (IAP)
    - ✓ Time impact analysis (TIA)
- Non-critical path techniques
- Delays by subcontractors

Critical Path Techniques

(Delay analysis key terms – Review)

Cause and effect vs. effect and cause

1. **Cause and effect type analysis**
   - ❖ Start with the **identification** and **description** of a **cause** and **then** its **impact**

2. **Effect and cause type analysis**
   - ❖ **Identifying critical delay (an effect)** and then what might **have caused** that **delay**

Cause			*Effect*	
Delay Event	***Risk Owner***	***Delay***	***Activity Impacted***	***Delay***
Late completion of sample	Contractor	5 days	Façade construction	5 days
Late inspection	Owner	5 days	Façade construction	5 days

Contemporaneous vs. after-the-fact

1. For **Contemporaneous analysis**
   - ❖ **Cause and effect methods** are recommended
     - ✓ Time impact analysis

1. For **After-the-fact analysis**
   - ❖ **Effect and cause methods** are **generally** more reliable

Because consider **all causes** of the **delay incurred**.

Prospective vs. retrospective

- **Delay impact** is determined in **one** of **two different ways**:

1. **Prospective** delay analysis
   - It identifies the **likely impact** of **historical progress** or **delay events** on a **completion date**.
   - The **conclusion** of this analysis **may not match** the **as-built schedule** because

     *the **contractor's actual performance** **may** well have been **influenced** by the effects of attempted **acceleration**, **re-sequencing** or **redeployment** of **resources** in order to **try to avoid liability** for **liquidated damages** or due to **other Employer and Contractor Risk Events**.*

2. **Retrospective** delay analysis
   - It identifies the **actual impact** of the **delay events** on the **identified actual** or **as-built critical path**

Prospective vs. retrospective

1. The delay events are **happening** or **going to happen**, and

   your **objective** is to **ESTIMATE** the impacts from the delays so that the contractor and owner can make **new agreement**.

   ❖ This analysis is often performed while the project is **in progress**.

   ✓ **"Contemporaneous Delay Analysis" or "Prospective Delay Analysis"**

❑ The delay events **have happened already**, and

your **objective** is to **QUANTIFY** the delays and **IDENTIFY** the Responsibility by using **actual data**.

❖ This analysis is usually performed **after** the events **happened** or after the project is **completed**.

✓ **"Forensic Delay Analysis" or "Retrospective Delay Analysis"**

Criticality

- **Criticality** is determined in **one** of **three different ways**:

1. **Purely prospective critical path assessments**
   - It adopts the **perspective evident** at the **outset** of the project **only** and **take no account** of **progress achieved**.

2. **Contemporaneous critical path assessments**
   - It adopts an **evolving perspective** **over** the **course of the works** and **take account** of the **effect** that **both historical progress** and **changes** in the strategy for the **future prosecution** of the works have on **predicted criticality.**

3. **Retrospective critical path assessments**
   - It adopts the **perspective evident** at the **end** of the project.

Importance of critical path

- **CPM schedules** can **benefit Owners** and **Contractors**
  - **But Contractors**, **Owners**, and **schedule analysts** must all become **proficient** in the **application** of **these scheduling tools**.
- The **longest path** may **have zero float** along its **(1) entire path**, **(2) a portion of its path**, or **(3) nowhere on the path.**
  - **This means** that it is **possible**, **even likely**, that **certain activities** on the **critical path** will **actually have float**.
    - ✓ A **close look** at the **schedule logic** will reveal **why the float** on these activities **makes sense**.

Often, this float is a function of a constraint that is modeling a Contract requirement or other known construction restriction

Importance of critical path

Understanding how to identify shifts in the critical path is essential to properly allocate critical Project delays.

- The **analysis techniques** employed by the **analyst** should be such that the **critical path** of the Project is **known for every day of the Project**.
  - The **advanced features** of **current CPM software** have given us **powerful tools** that provide a **high level of precision** in the **analysis process**.

While the activities along the **critical path** may have **varying float values**, many schedules **still have critical paths** with **zero float**.

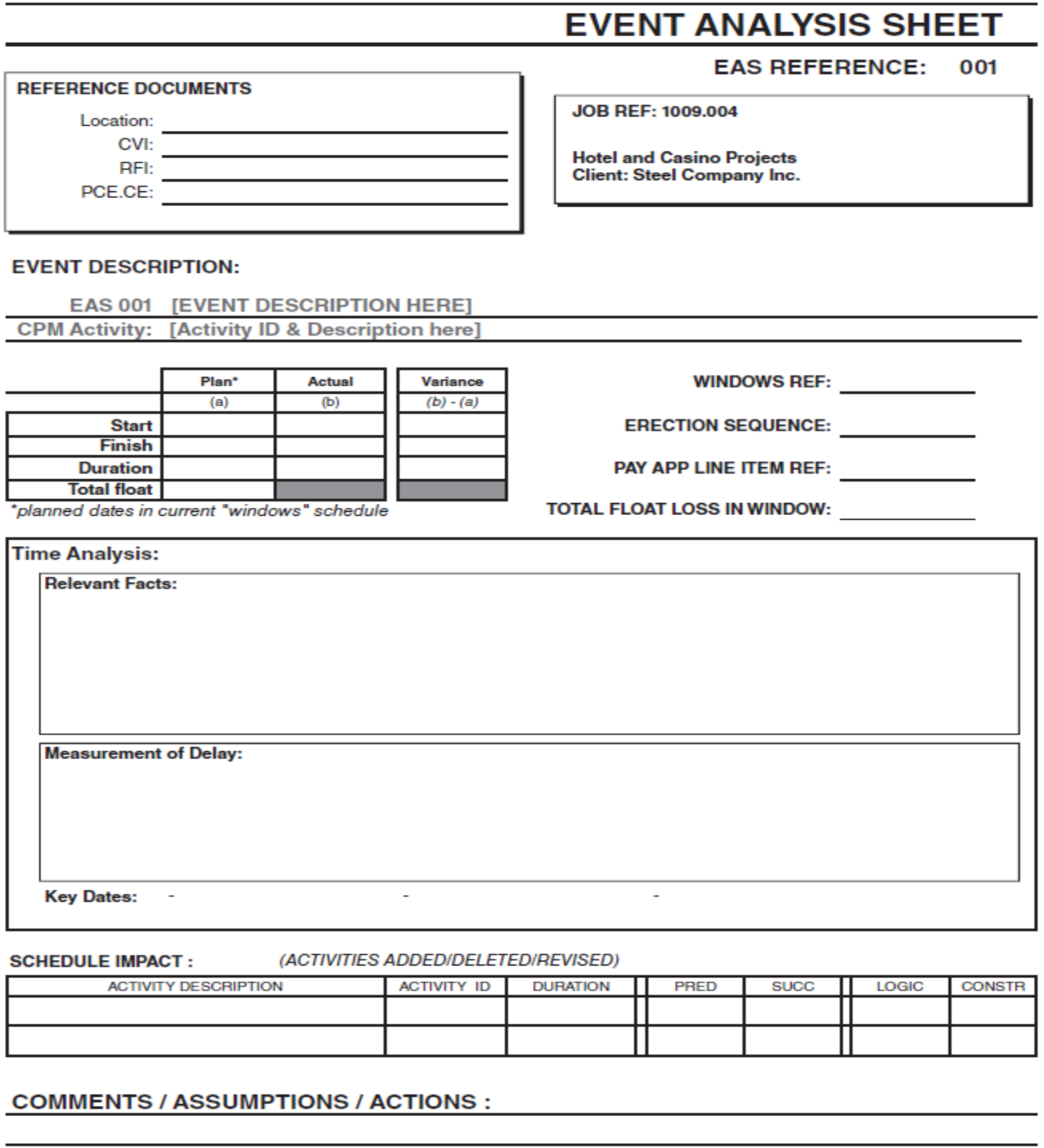
***For simplicity purposes**, **most of the examples** used in this course will **refer to zero float critical paths**.*

Critical Path Techniques

(Delay Analysis Using Prospective Methods)

STEP 7: Performing delay analysis procedure (CPs 4 and 11) (Contempo

- **Event Analysis Sheet**
- **CVIs** (confirmation of verbal instructions)
- **PCEs** (potential compensation events)
- A **list of potential delay events** should then be created.
- For **each potential delay event**, an **"event analysis sheet"** should be prepared.



EVENT ANALYSIS SHEET

EAS REFERENCE: 001

REFERENCE DOCUMENTS

Location: _____
CVI: _____
RFI: _____
PCE.CE: _____

JOB REF: 1009.004

Hotel and Casino Projects
Client: Steel Company Inc.

EVENT DESCRIPTION:

EAS 001 [EVENT DESCRIPTION HERE]
CPM Activity: [Activity ID & Description here]

	Plan* (a)	Actual (b)	Variance (b) - (a)
Start			
Finish			
Duration			
Total float			

*planned dates in current "windows" schedule

WINDOWS REF: _____
ERECTION SEQUENCE: _____
PAY APP LINE ITEM REF: _____
TOTAL FLOAT LOSS IN WINDOW: _____

Time Analysis:

Relevant Facts:

Measurement of Delay:

Key Dates: - - -

SCHEDULE IMPACT : (ACTIVITIES ADDED/DELETED/REVISED)

ACTIVITY DESCRIPTION	ACTIVITY ID	DURATION	PRED	SUCC	LOGIC	CONSTR

COMMENTS / ASSUMPTIONS / ACTIONS :

STEP 7: Performing delay analysis procedure (CPs 4 and 11)

- **Details of all the delay issues** identified should be recorded in a **delay register** (below table).
- This table should capture **all delays**.
- This table could be more complex.

Ref no.	Cause and effect of delay or disruption	Delay to section or part of works	Delay to competition date	Contract clause relevant to delay	Date of delay notice and particulars
1.	**Under-slab drainage** Additional works arising out of discovery of ground beam clash	16 days	4 days	25 Relevant event 25.4.5.1	Contractor's letters: November 23 2005

STEP 7: Performing delay analysis procedure (CPs 4 and 11)

❑ CP 4 in SCL Protocol:

4. Do not 'wait and see' regarding impact of delay events (contemporaneous analysis)

The parties should attempt so far as possible to deal with the time impact of Employer Risk Events as the work proceeds (both in terms of EOT and compensation). Applications for an EOT should be made and dealt with as close in time as possible to the delay event that gives rise to the application. A 'wait and see' approach to assessing EOT is discouraged. Where the Contractor has complied with its contractual obligations regarding delay events and EOT applications, the Contractor should not be prejudiced in any dispute with the Employer as a result of the CA failing to assess EOT applications. EOT entitlement should be assessed by the CA within a reasonable time after submission of an EOT application by the Contractor. The Contractor potentially will be entitled to an EOT only for those events or causes of delay in respect of which the Employer has assumed risk and responsibility (called in the Protocol Employer Risk Events) that impact the critical path.

STEP 7: Performing delay analysis procedure (CPs 4 and 11)

❑ Contemporaneous analysis procedure

- ❖ **Step 7** sets out a **recommended procedure** to be **followed in order** to deal **efficiently and accurately** with EOT applications during the **course of the project.**
- ❖ **This procedure** assumes **Steps 1 to 6** have been **followed.**
- ❖ **Step 7** does **not intend** to be **incorporated into a contract.**

Contemporaneous analysis – Why preferred?

- The **contemporaneous** project schedules are the **preferred tool** to **measure Project delay** because they were used by the **project participants** to

  manage and **construct** the project at a **moment in time** based on the **known Project conditions**.

  1. By using the **contemporaneous schedules** and **updates**, and
  2. By **tracking delays** as they **occur throughout the project**,

     there is **no need** to attempt to **inject information** that is **known at a later date**.

Contemporaneous analysis – Why preferred?

ASCE Standard ANSI/ASCE/CI 67-17 (Schedule Delay Analysis)

7.3 CONSIDERATION SHOULD BE INCLUDED AS TO HOW DELAYS WERE EVALUATED BY THE PARTICIPANTS DURING THE PROJECT

- Although **delay events** should be **recognized and measured during the project** as the project progresses,

  in practice they are **not always identified contemporaneously**.

- During expert analysis, the **more common industry practice** is to measure the delays in an **after-the-fact analysis**,

  which **more accurately** defines the delay events that **occurred** on a project.

- **Although** this process may reveal what may be considered **bad decisions with hindsight**,

  contemporaneous decisions affecting project delay **still may be justifiable**.

Contemporaneous analysis – What schedule to measure delay?

Do not create schedules after-the-fact to measure delays

- Using a **schedule** created **after the fact** to measure and identify project delay, however, has **two weaknesses**:
  1. The schedule does **not depict** the **original construction plan**
  2. The schedule may include **predetermined conclusions** concerning delays

When possible, it is always best to use the contemporaneous Project schedules to measure Project delay while the analyst may make very minor modifications to the contemporaneous schedule to account for obvious errors.

Delay analysis using prospective methods – Introducing methods

Method of Analysis	Analysis Type	Critical Path Determined	Delay Impact Determined	Requires
Impacted As-Planned Analysis	Cause & Effect	Prospectively	Prospectively	• Logic linked baseline programme. • A selection of delay events to be modelled.
Time Impact Analysis	Cause & Effect	Contemporaneously	Prospectively	• Logic linked baseline programme. • Update programmes or progress information with which to update the baseline programme. • A selection of delay events to be modelled.

Delay analysis using prospective methods – Comparing methods

The Information Required					
	Baseline programme	Logic linked baseline programme	As-built data	Delay events to model	Up to date programmes/ process information
Impacted As-Planned					
Time Impact					

Delay analysis using prospective methods – References

Delay analysis using prospective methods

The following procedure proposed in this course provided by combining

1. ***AACE 52R-06***
2. ***AACE 29R-03***
3. ***SCL Protocol***
4. ***Construction Delays Book (Third Edition)***
5. ***Delay Analysis in Construction Contracts Book (Second Edition)***
6. ***My experience***

Impacted As-Planned (IAP)

Delay analysis using prospective methods – Introducing methods

Method of Analysis	Analysis Type	Critical Path Determined	Delay Impact Determined	Requires
Impacted As-Planned Analysis	Cause & Effect	Prospectively	Prospectively	• Logic linked baseline programme. • A selection of delay events to be modelled.
Time Impact Analysis	Cause & Effect	Contemporaneously	Prospectively	• Logic linked baseline programme. • Update programmes or progress information with which to update the baseline programme. • A selection of delay events to be modelled.

Delay analysis using prospective methods – Impacted as planned analysis

❑ Definition

❖ In this approach, the **analyst** identifies the **as-planned schedule** and then **inserts** into this schedule the **changes** that it **believes**

1. **Will cause** project delays
2. **May have caused** project delays

Why should not be used as forensic analysis?
Think about it!

✓ The **source** for **these changes** is **only** the **perceived delays** noted during **construction**.

✓ **This type** of analysis considers **only** the project team's **original plan** and the **delay** being analyzed.

This is done on "baseline schedule"

Impacted As-Planned (IAP)

(Contemporaneous or Prospective)

Impacted as planned analysis – Contemporaneous or prospective

How to use?

1. **Use** the **initial as-planned (baseline)** schedule for the project.
2. **Incorporate** the **delay event** as **activity** in the as-planned schedule and **link it to all activities** that it will impact.
3. **Recalculate** the **completion date**.
4. The **difference** between
   1. **Initial completion date** in the as-planned (baseline) schedule and
   2. **Completion date** on the recalculated schedule

   will constitute the effect of the delay.

Impacted as planned analysis – Contemporaneous or prospective

- **Example**

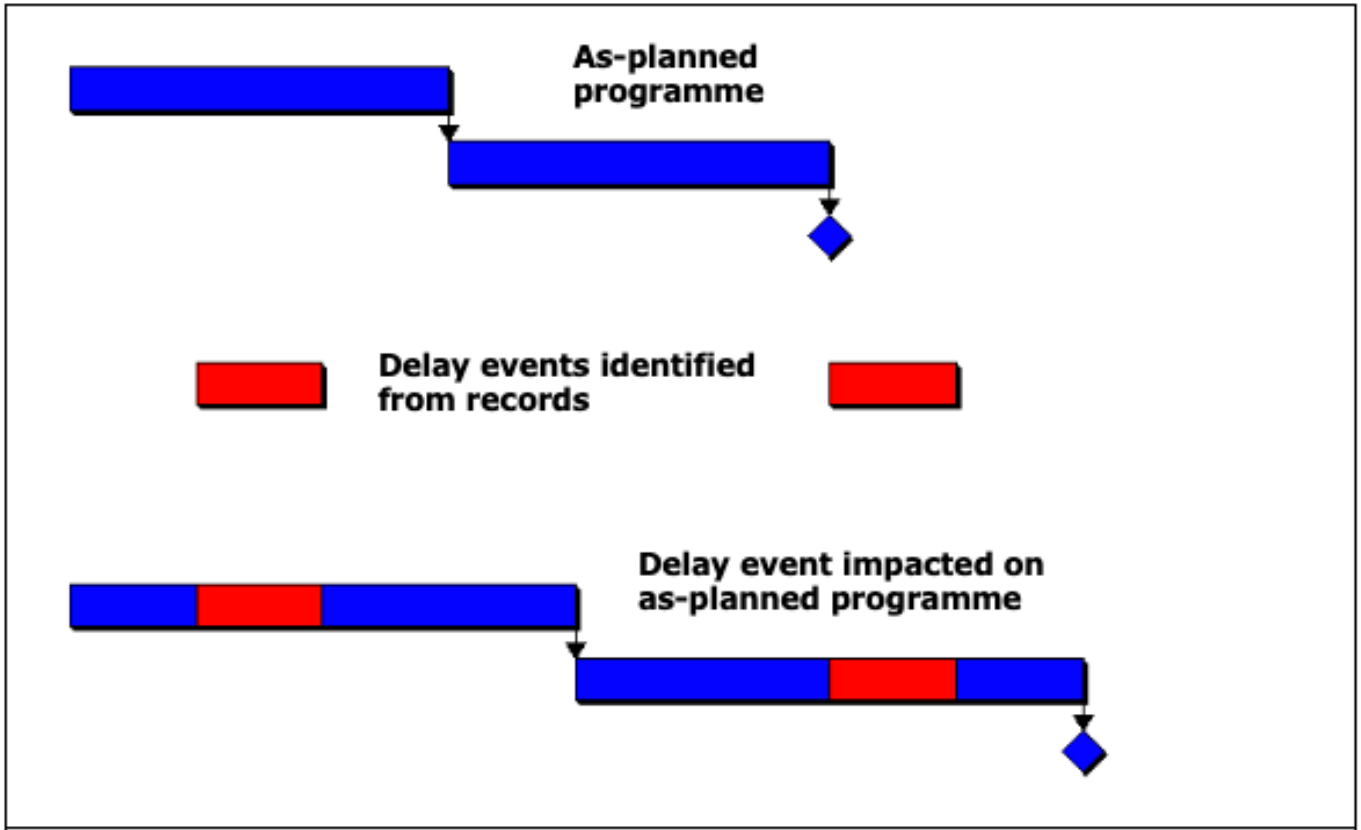
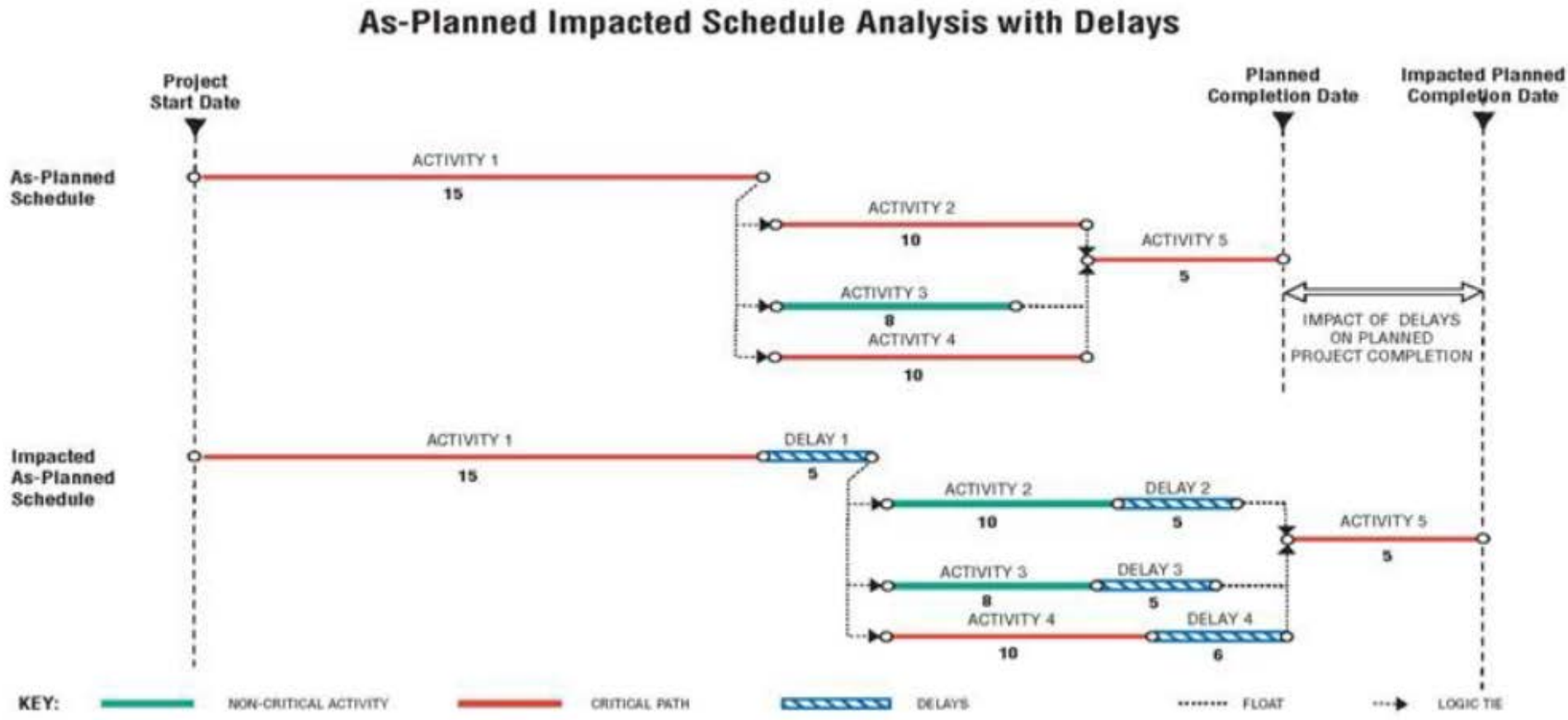


Diagram illustrating the Impacted As-Planned technique.

Could it be performed using windows?

Impacted as planned analysis – Contemporaneous or prospective

- **Example:**



Do the courts accept it as a forensic analysis?

Impacted as planned analysis – Contemporaneous or prospective

Example: Court decision

"We have found that [his] analysis systematically excluded all delays and disruptions except those allegedly caused by the Government … We conclude that his analysis was inherently biased, and could lead to but one predictable outcome … To be credible, a contractor's CPM analysis ought to take into account, and give appropriate credit for all of the delays which were alleged to have occurred."

Haney v. United States 30 CCF ¶ 70, 1891], 676 F.2d 584 (Ct. Cl. 1982); Pathman Construction Co. , ASBCA No. 23392, 85-2 BCA ¶ 18,906

Could it be used for compensation calculation?

Impacted as planned analysis – Contemporaneous or prospective

❑ SCL view

❖ *The **SCL Protocol** envisaged the IAP technique as one which would **assist** in demonstrating **extension of time entitlement only**, and **not prolongation costs**.*

Do not use IAP as prospective for calculating the compensation or LD!

❖ While **IAP models** can only estimate the impact of events prospectively,

It is foreseeable that the IAP model could be used as the basis for estimating prolongation on the basis of **pre-agreed rates**

if parties are inclined to **accept** the results of such an analysis.

How about concurrency?

Impacted as planned analysis – Contemporaneous or prospective

❑ SCL view

- ❖ *It was **not concerned** with using the IAP technique for identifying **concurrent delays** if used as a **retrospective**.*
  - o *Because SCL believes in **true concurrency**!*
    - ✓ *This can only be done with **as-built records** and approaches which rely on **as-built programmes**.*

Cannot calculate true concurrency!

**So, if used prospective,
what to do to resolve this problem?**

Impacted as planned analysis – Contemporaneous or prospective

- *However, the **AACEI** recognizes that the approach is able to identify **'approximate concurrency'** for the purposes of estimating*
  1. *Concurrent delay and*
  2. *Extension of time entitlement*

Because AACE believes in functional theory as well!

Now, you know why I recommended to use functional theory if you consider to use prospective methods!

What are the requirements of using IAP?

Impacted as planned analysis – Contemporaneous or prospective

The only schedule required to carry out an IAP is a baseline schedule that

1. Contractually compliant
2. Represents a contractor's true intention prior to commencing any works

What if the available baseline contains identifiable logical or duration errors?

Impacted as planned analysis – Contemporaneous or prospective

What if the available baseline contains identifiable logical or duration errors?

Don't use this method,

unless

there is an agreement to use it as a negotiating tool between contractor and employer!

Impacted as planned analysis – Contemporaneous or prospective

Could it be used as a retrospective method?

Yes, but not recommended at all!

This is the reason that SCL Protocol considers this as Prospective approach!

But it have been using in Iran and it is so prevalent?

Ok, I will teach you how to improve the accuracy of this approach when using as Retrospective!

Impacted As-Planned (IAP)

(Forensic or Retrospective)

Impacted as planned analysis – Forensic or retrospective

How to use?

1. Once a **baseline** for analysis is **identified**, then either, or both, **employer delay event (EDE)** and **contractor delay event (CDE)** are added to the baseline programme.
   a) If they are added **independently**, this is known as a **'non-integrated IAP'** (with either CDE or EDE, but not both).
   b) If both are added **jointly**, then this is a **'combined IAP'.**
      - Combined IAP models require the impacts to be inserted in the **chronological order** in which they **first arose**.

Impacted as planned analysis – Forensic or retrospective

How to use?

1. Once a **baseline** for analysis is **identified**, then either, or both, **employer delay event (EDE)** and **contractor delay event (CDE)** are added to the baseline programme.

- The insertion can take may forms, including:
  - Delaying the start of an existing, or inserted, activity with a constrained start date.
  - Delaying the finish of an existing, or inserted, activity with a constrained finish date.
  - Increasing the duration of an existing activity.
  - Increasing or decreasing the hours available during a working week.
  - Inserting a new fragnet or activity, logically linked to existing activities in the programme.
  - Adding or deleting existing logical links to reflect the impact of changed conditions and dependencies.

Which method is recommended?

Impacted as planned analysis – Forensic or retrospective

How to use?

1. Once a **baseline** for analysis is **identified**, then either, or both, **employer delay event (EDE)** and **contractor delay event (CDE)** are added to the baseline programme.

- The insertion can take may forms, including:
  - Delaying the start of an existing, or inserted, activity with a constrained start date.

Some analysts insert activities with start constraints, thus avoiding the need to provide a predecessor in the existing baseline programme.

This is appropriate in certain circumstances but should be avoided when natural construction predecessors can be identified in the baseline programme.

  - Delaying the finish of an existing, or inserted, activity with a constrained finish date.
    Same thing…

Impacted as planned analysis – Forensic or retrospective

How to use?

1. Once a **baseline** for analysis is **identified**, then either, or both, **employer delay event (EDE)** and **contractor delay event (CDE)** are added to the baseline programme.

- The insertion can take may forms, including:
  - Increasing the duration of an existing activity.
  - Increasing or decreasing the hours available during a working week.
  - Adding or deleting existing logical links to reflect the impact of changed conditions and dependencies.

So, which one?

Impacted as planned analysis – Forensic or retrospective

How to use?

1. Once a **baseline** for analysis is **identified**, then either, or both, **employer delay event (EDE)** and **contractor delay event (CDE)** are added to the baseline programme.

This is performed by inserting additional tasks as discrete activities, complete with logical relationships and durations to the original contract baseline schedule.

Each CDE or EDE activity requires the following:

1. **Estimated duration**
2. **List of logical predecessors**
3. **List of logical successor**

Impacted as planned analysis – Forensic or retrospective

- **How to use?**

Any method of insertion must be recorded as part of a transparent and auditable process.

Impacted as planned analysis – Forensic or retrospective

How to use?

CDE and EDE can be inserted:

1. **One at a time**
2. **All at once**

2. The resulting delay impact on the completion date, is then measured and recorded.

   a) **<u>One at a time:</u>** then the impacted completion date is recorded **event by event.**

      ✓ Both CDE and EDE can be inserted in this way.

      ✓ Concurrent effect is better calculated in this method.

   b) **<u>All at once:</u>** then impacted completion date is recorded **once at a time**.

Impacted as planned analysis – Forensic or retrospective

❑ Practical procedure for CC-IAP:

What should be done for <u>combined chronological</u> impacted as planned (CC-IAP)?

1. <u>Both</u> CDE and EDE delays are identified and listed <u>chronologically</u>.
2. <u>Each delay</u> is inserted <u>individually</u> and <u>cumulatively</u> until <u>all delays</u> have been inserted into the program ***(CC-IAP developed).***
3. <u>Depending</u> on whether the impact was caused by either a CDE or an EDE, the critical delay to completion is **"banked"** into a respective category and **tabulated**.
   - ✓ *Sum of CDEs = Non-excusable, non-compensable delays, and LDs*
   - ✓ *Sum of EDEs = Excusable and Compensable delays*

So, what to do for <u>concurrent delays</u>?

Impacted as planned analysis – Forensic or retrospective

❑ Practical procedure for CC-IAP:

What should be done for <u>combined chronological</u> impacted as planned (CC-IAP)?

4. Prepare and insert only EDE in IAP to find concurrent delays ***(EDE-IAP developed)***
   - ✓ *Sum of EDEs-CC-IAP – EDE-IAP = Concurrent delays (excusable but non-compensable)*
     - o While this is **<u>not true concurrent delay</u>**, because it is based on a <u>theoretical prospective model</u>, it provides a measure of **<u>approximate concurrency</u>**.

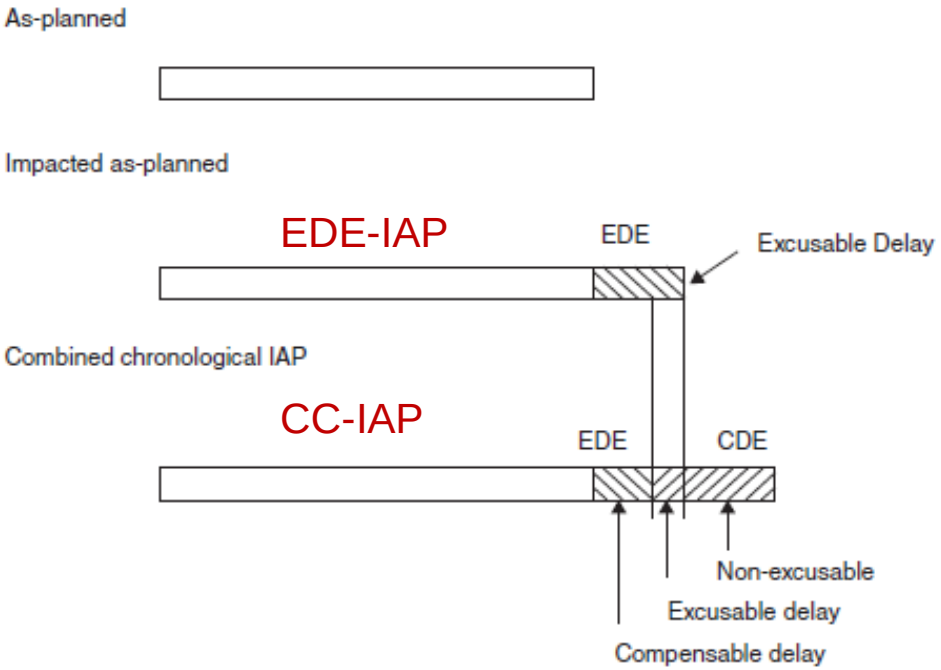
This is again the reason I told you to used "Functional Theory"

What should be done for <u>Excusable but non-compensable</u>?

Impacted as planned analysis – Forensic or retrospective

❑ Practical procedure for CC-IAP:

Combined



This could calculate the **approximate concurrency**

Impacted as planned analysis – Forensic or retrospective

However, payment for time-related costs during this approximate period can only be estimated by way of average daily rates, or some other pre-agreed daily rate which is acceptable to both parties.

The resulting compensable delay period will not identify

1. **Actual period in which the delay was being experienced, or**
2. **Actual delay which was experienced to the completion date**

Impacted as planned analysis – Forensic or retrospective

❑ Practical procedure for NI-IAP:

What should be done for Non-integrated impacted as planned (NI-IAP)?

1. Impact of CDE separately from the EDE in two isolated models.
2. Compare two models:

I. Sum of CDEs > Sum of EDEs

- ✓ *CEDs = Non-excusable and LDs*
- ✓ *EDs = Excusable*
- ✓ *No compensation*

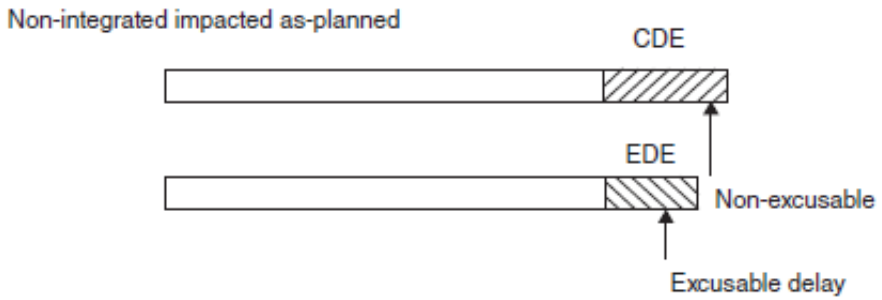
II. Sum of CDEs < Sum of EDEs = Difference is compensable delay

- ✓ *CEDs = Non-excusable and LDs*
- ✓ *EDs = Excusable*
- ✓ *Difference is compensable delay*

Impacted as planned analysis – Forensic or retrospective

❑ Practical procedure for NI-IAP:

Non-integrated



So, what to do for <u>concurrent delays</u>?

Impacted as planned analysis – Forensic or retrospective

❑ Practical procedure for NI-IAP:

What should be done for Non-integrated impacted as planned (NI-IAP)?

3. Estimate **CC-IAP** (again we need CC-IAP)
4. Compare **non-integrated CDE** with **CC-IAP**
   - ✓ *CC-IAP – Non-integrated CDE*
5. Compare the duration achieved from Step 4 with Non-integrated EDE
   - ✓ *Number achieved in Step 4 > Non-integrated EDE = No concurrency*
   - ✓ *Number achieved in Step 4 < Non-integrated EDE = Difference is concurrency*

Impacted as planned analysis – Forensic or retrospective

Example

Combined

Combined IAP model results.

Combined impacted liability table			Cumulative delay	
Event	Event type	Impacted completion date	EDE	CDE
Baseline		1-Jan-09		
001	EDE	2-Jan-09	1	
002	EDE	5-Jan-09	3	
003	CDE	8-Jan-09		3
004	EDE	10-Jan-09	2	
005	CDE	15-Jan-09		5
006	CDE	15-Jan-09		0
007	EDE	18-Jan-09	3	

Don’t forget to use negative sign for acceleration

Impacted as planned analysis – Forensic or retrospective

- It must be remembered that **these assessments** are **only estimates** of **approximate liability.**

- The **actual delay** experienced in total may **not be equal to the 17 days** of total delay determined by the **IAP model**.

Why?

Impacted As-Planned (IAP)

(Weaknesses)

Impacted as planned analysis – Weaknesses

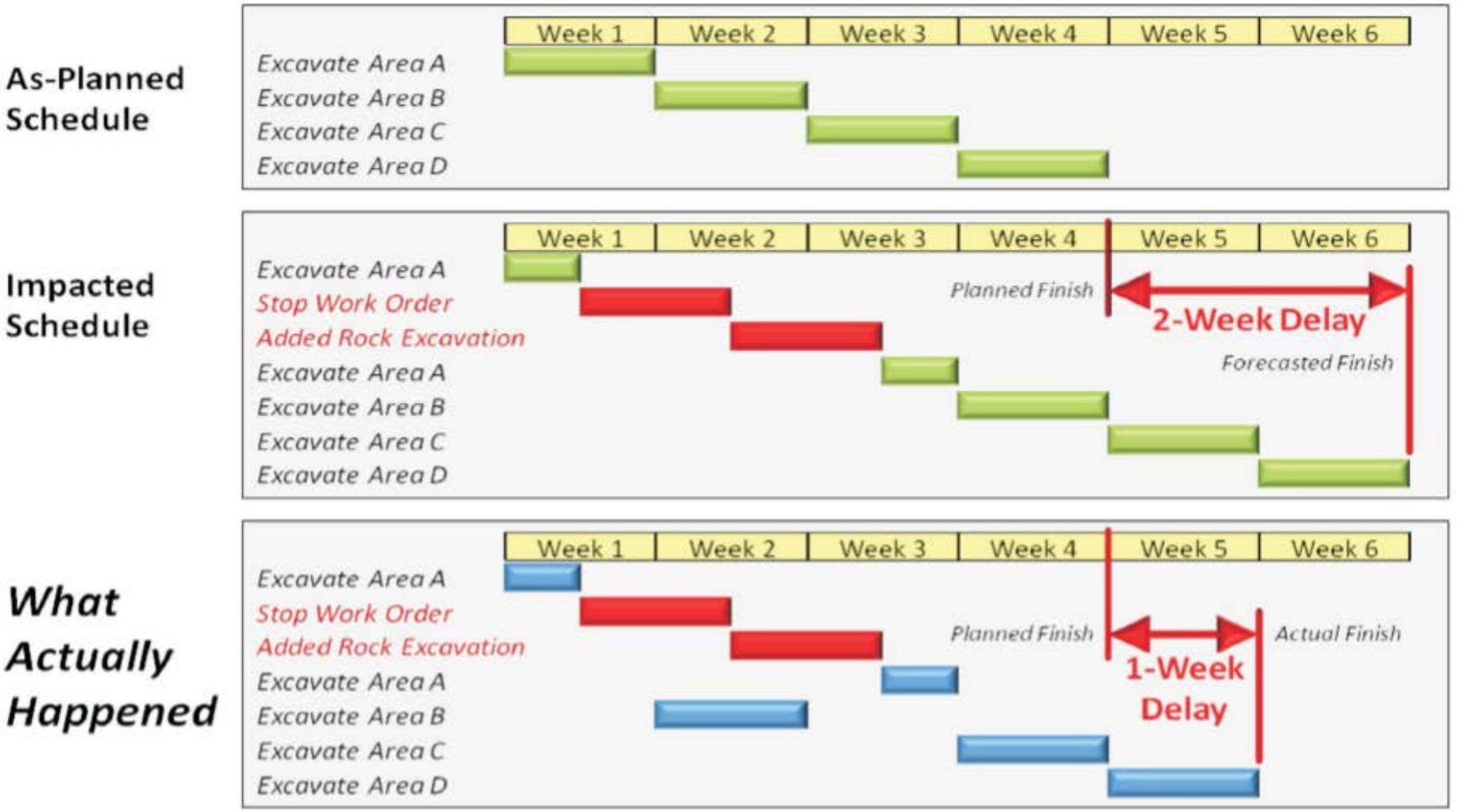
❑ Major weaknesses of this approach

❖ The difference between the **IAP impacted contract completion date** and the **actual contract duration** achieved can be explained by several factors:

- ✓ **Deviations** from the as-planned sequence,
  - o Out-of-sequence
- ✓ **Deviations** from the as-planned durations,
  - o Documentation problem and contemporaneous records
- ✓ **Additional delays** not considered in the IAP model
  - o Often **subjective** and **one-sided**
- ✓ **Mitigation** achieved along the critical path
- ✓ Changes in critical path
  - o **Most significantly**, it **does not consider** the **dynamic nature** of a **project** and the **critical path**.

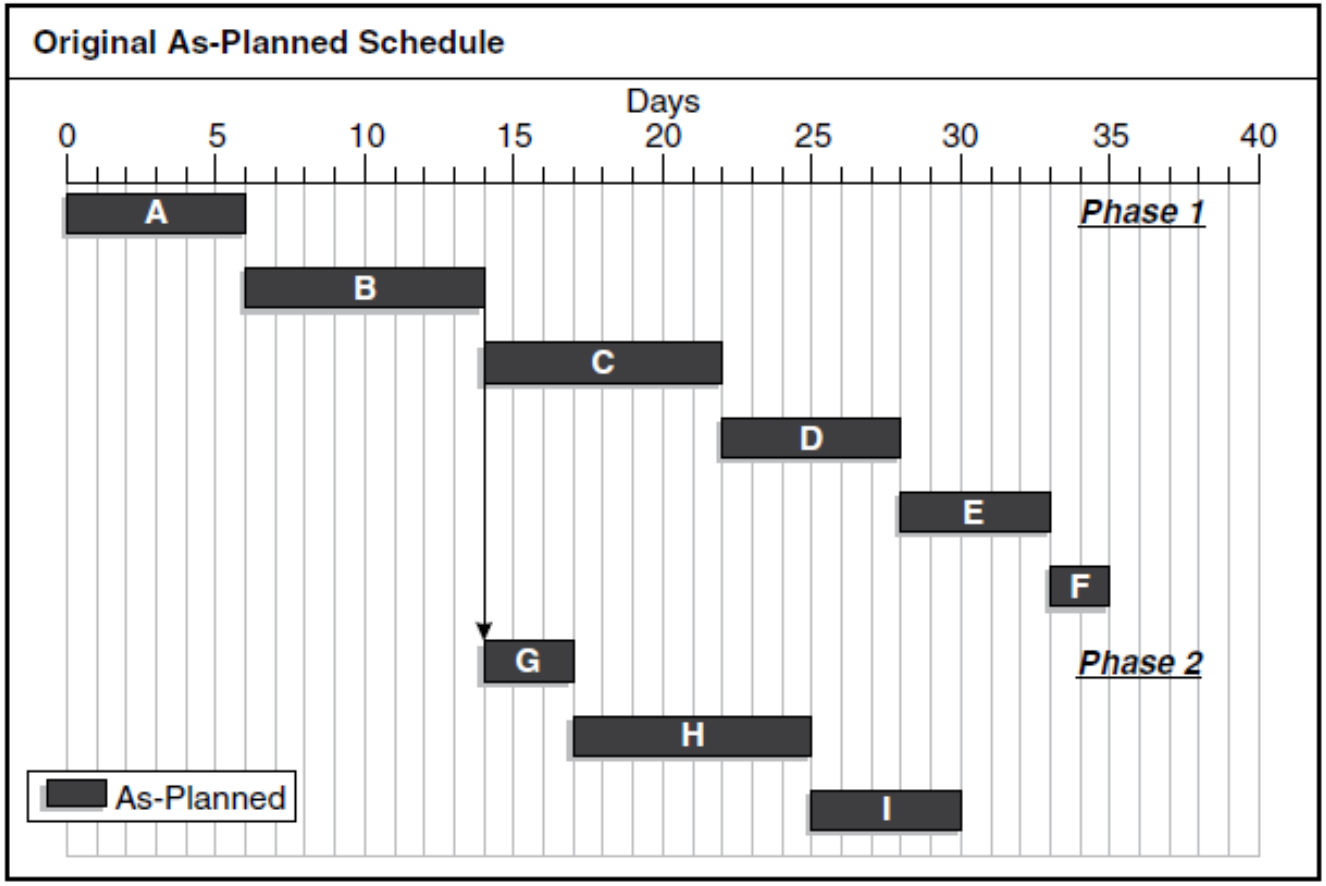
Impacted as planned analysis – Weaknesses

- **Major weaknesses of this approach**



Impacted as planned analysis – Weaknesses

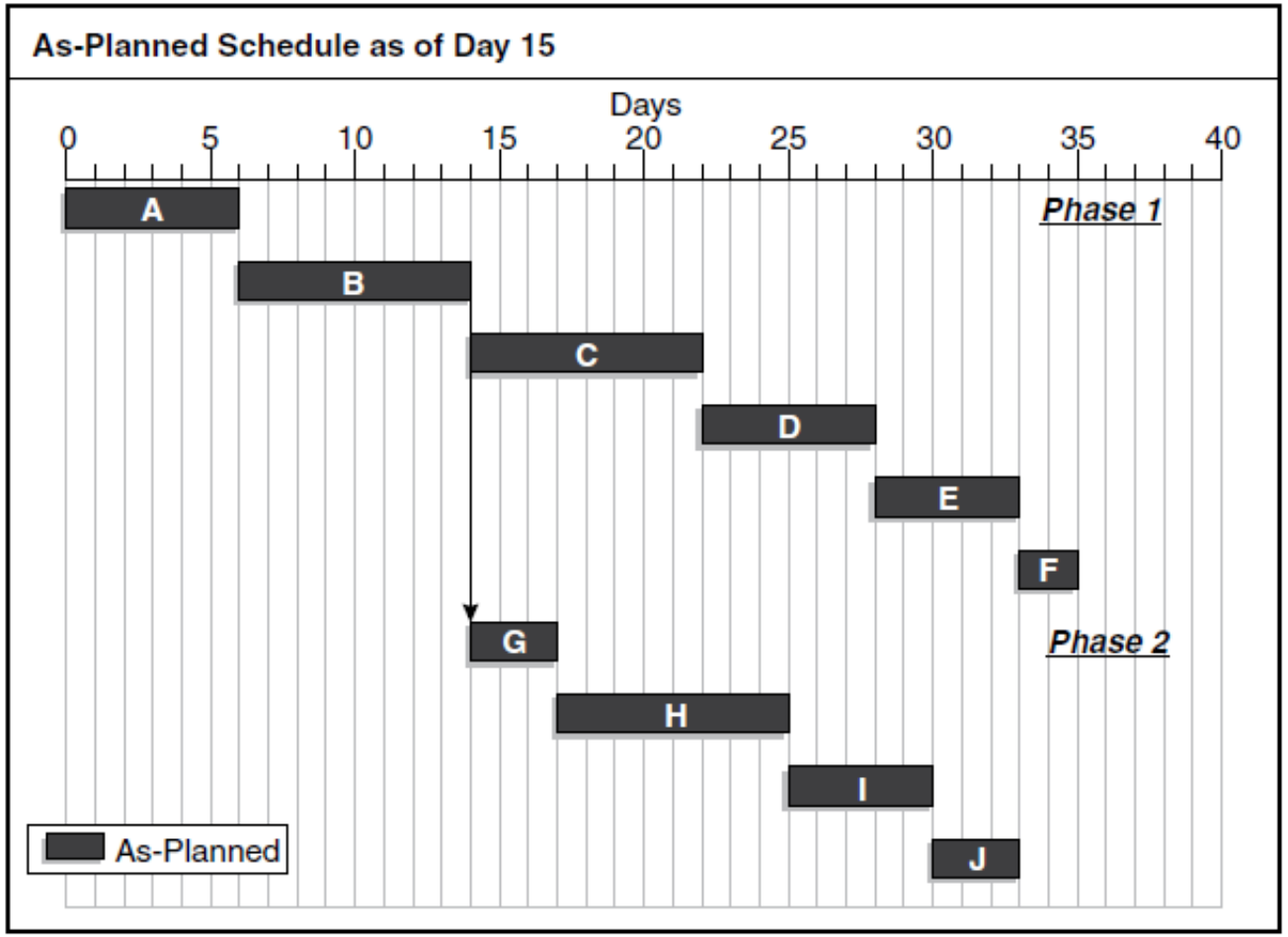
- **Example:** A through F must be performed in sequence.



Impacted as planned analysis – Weaknesses

- **Example:** On day 15, the contractor modifies its work and adds J with a duration of three days.

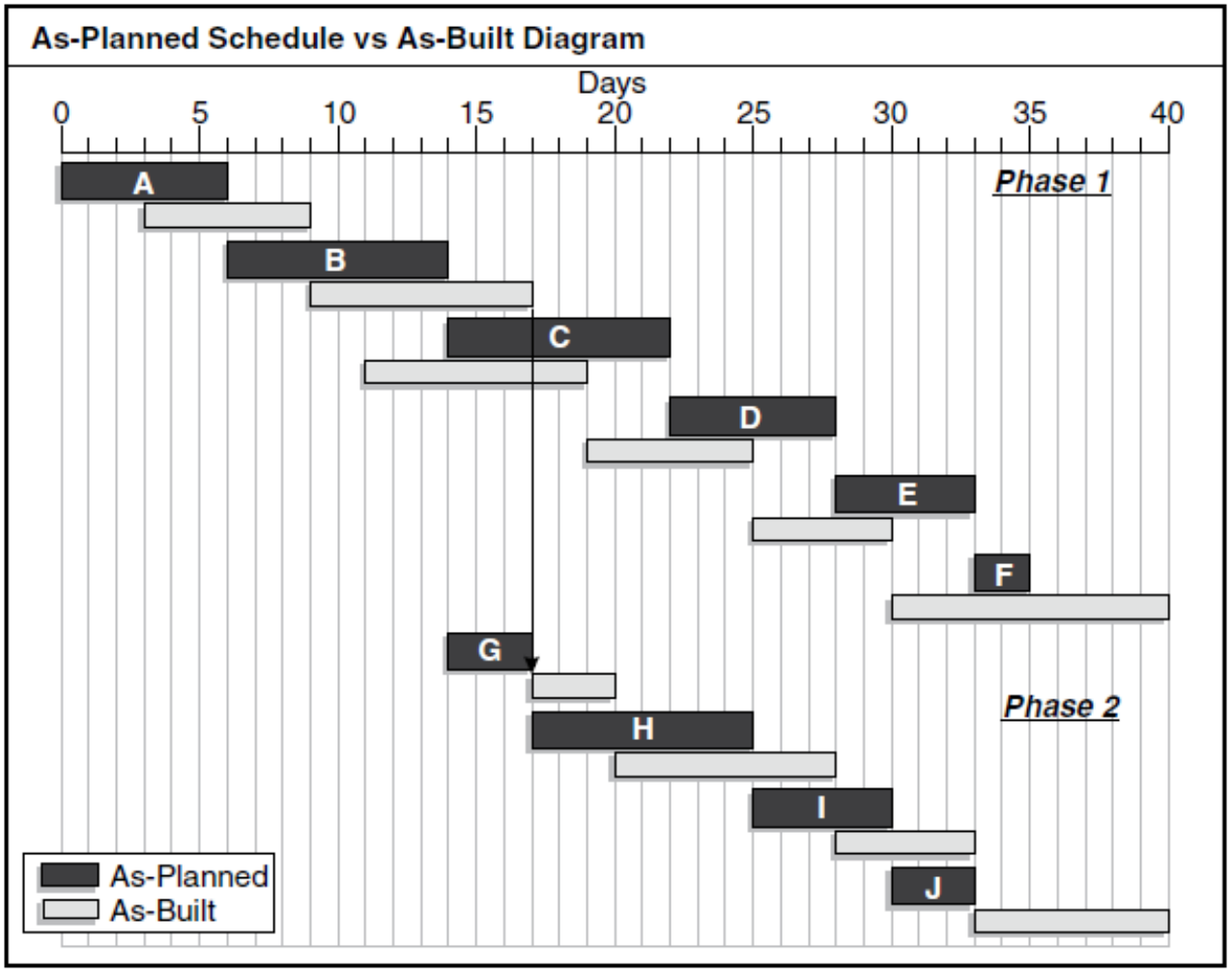
- So, nothing should be changed so far.



Impacted as planned analysis – Weaknesses

❑ **Example:** As-planned vs. as-built

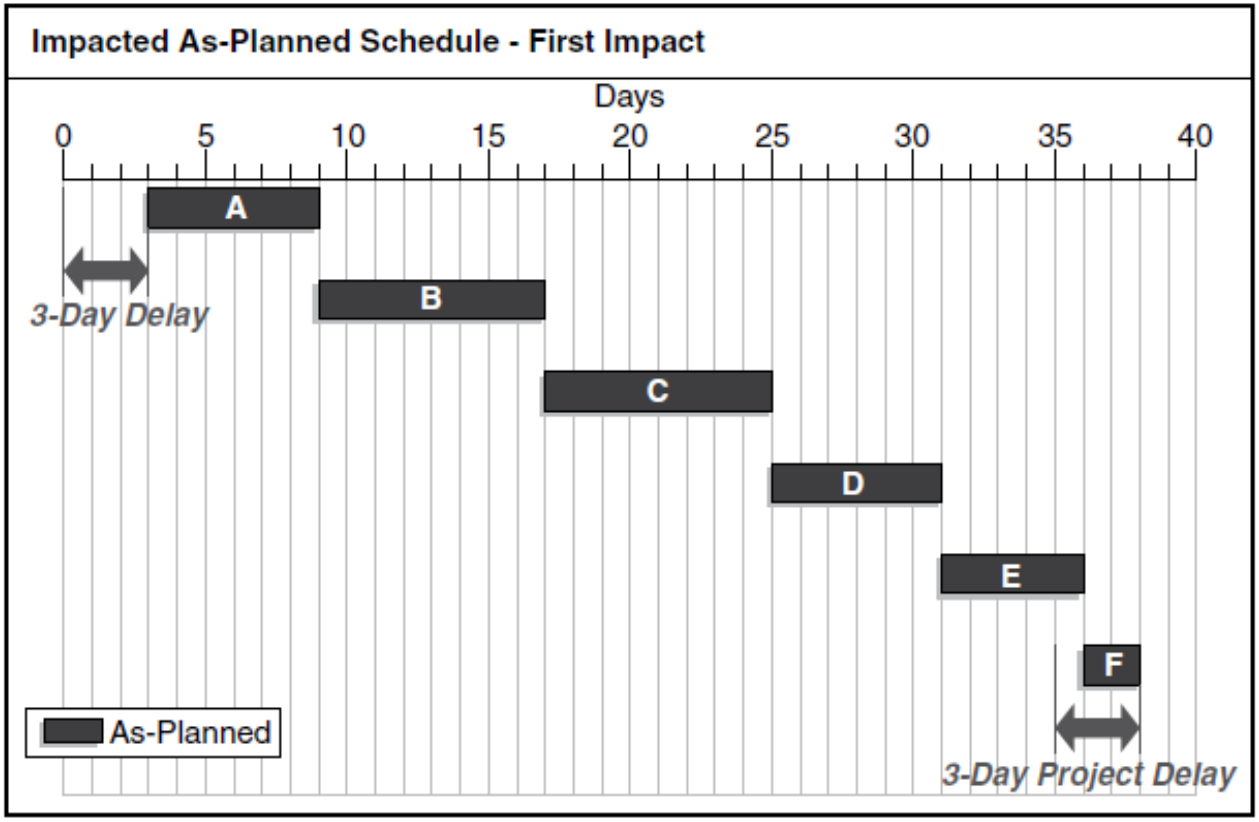
- The project is actually completed in 40 days (5 days delay)
- Activity A started three days late.
- Activity C started six days early and out of sequence.
- Activity F took eight days longer.
- Activity J took four days longer.



Impacted as planned analysis – Weaknesses

❑ **Example:** Impacted as-planned – First impact

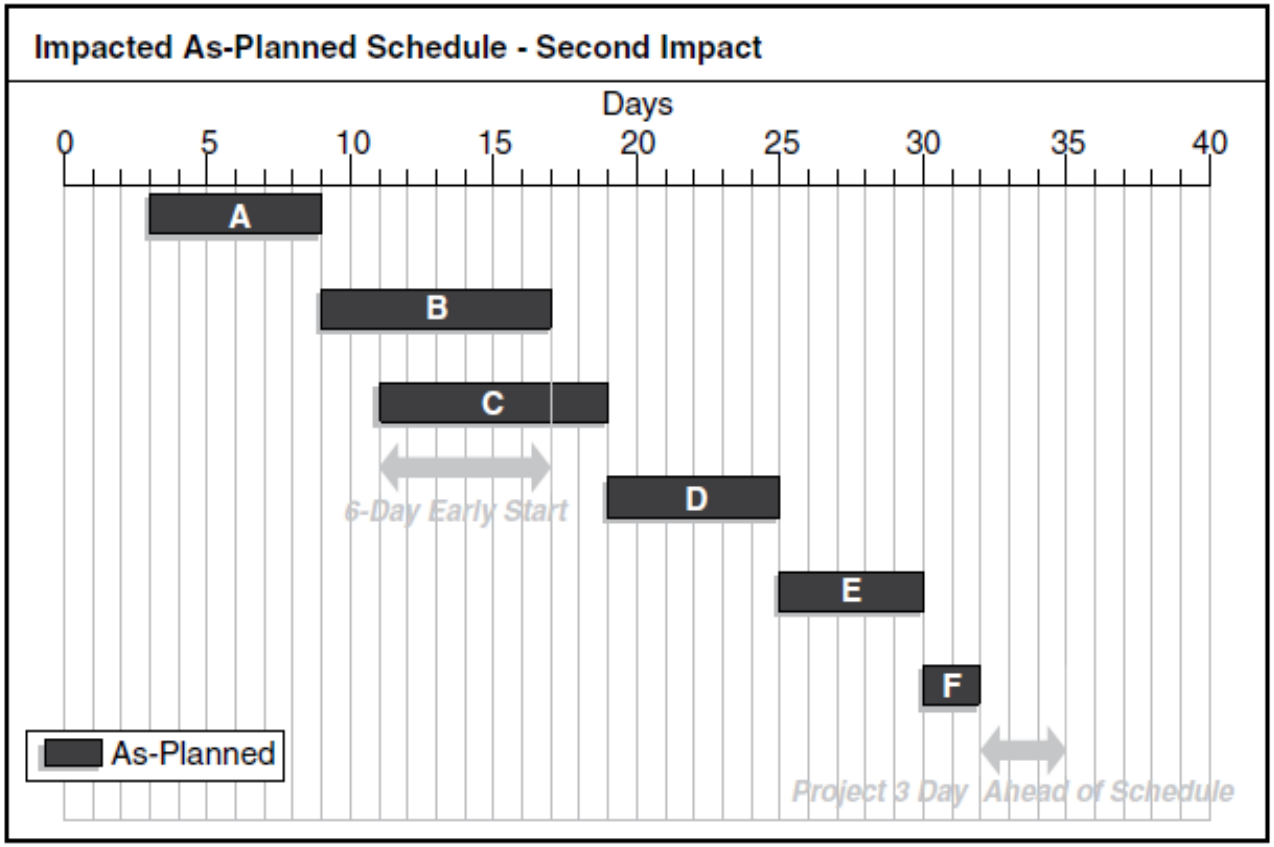
❖ Project delayed by three days because of the late start of Activity A.



Impacted as planned analysis – Weaknesses

❑ **Example:** Impacted as-planned – Second impact

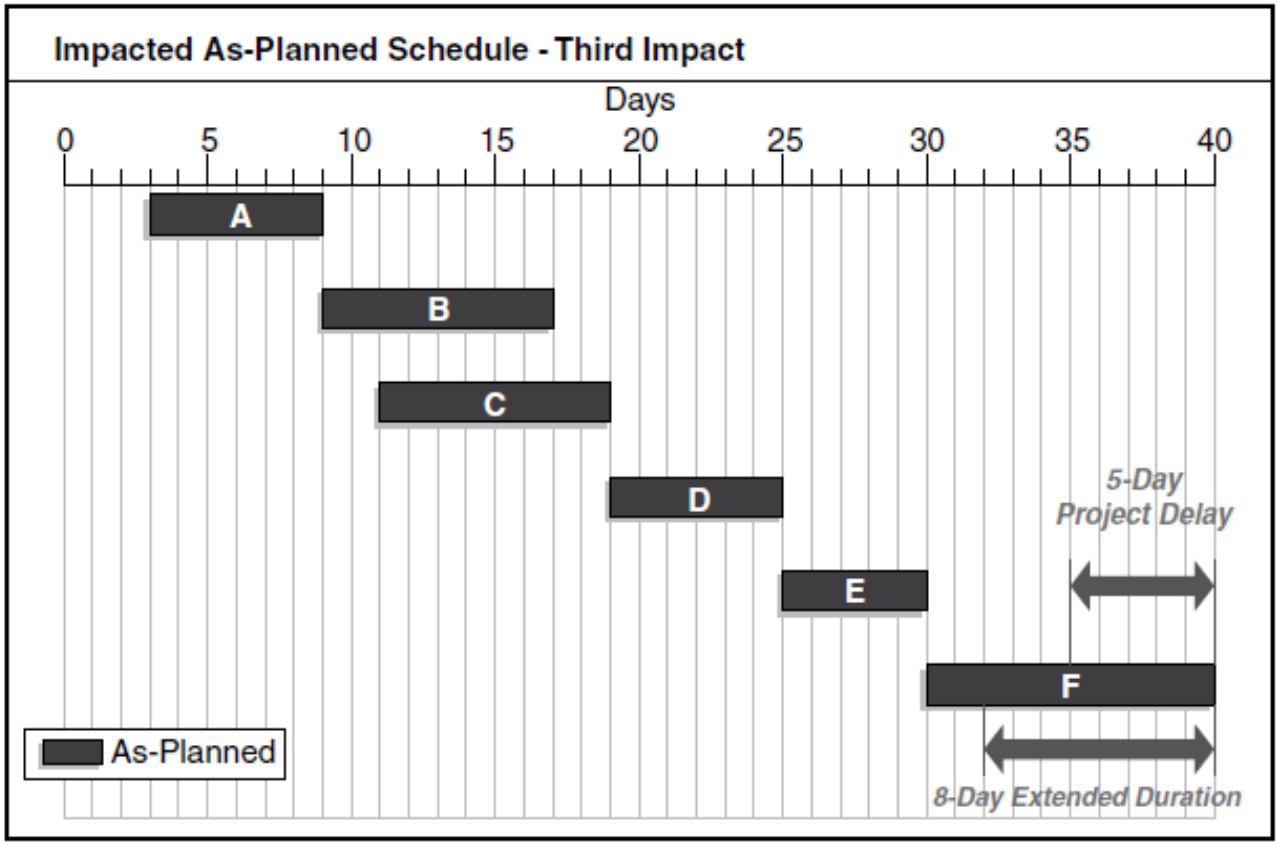
❖ Project ahead of schedule by three days because of the early start of Activity C.



Impacted as planned analysis – Weaknesses

❑ **Example:** Impacted as-planned – Third impact

❖ Project delayed a total of five days due to the extended duration of Activity F.



Impacted as planned analysis – Weaknesses

- **Example:** Impacted as-planned – Final conclusion

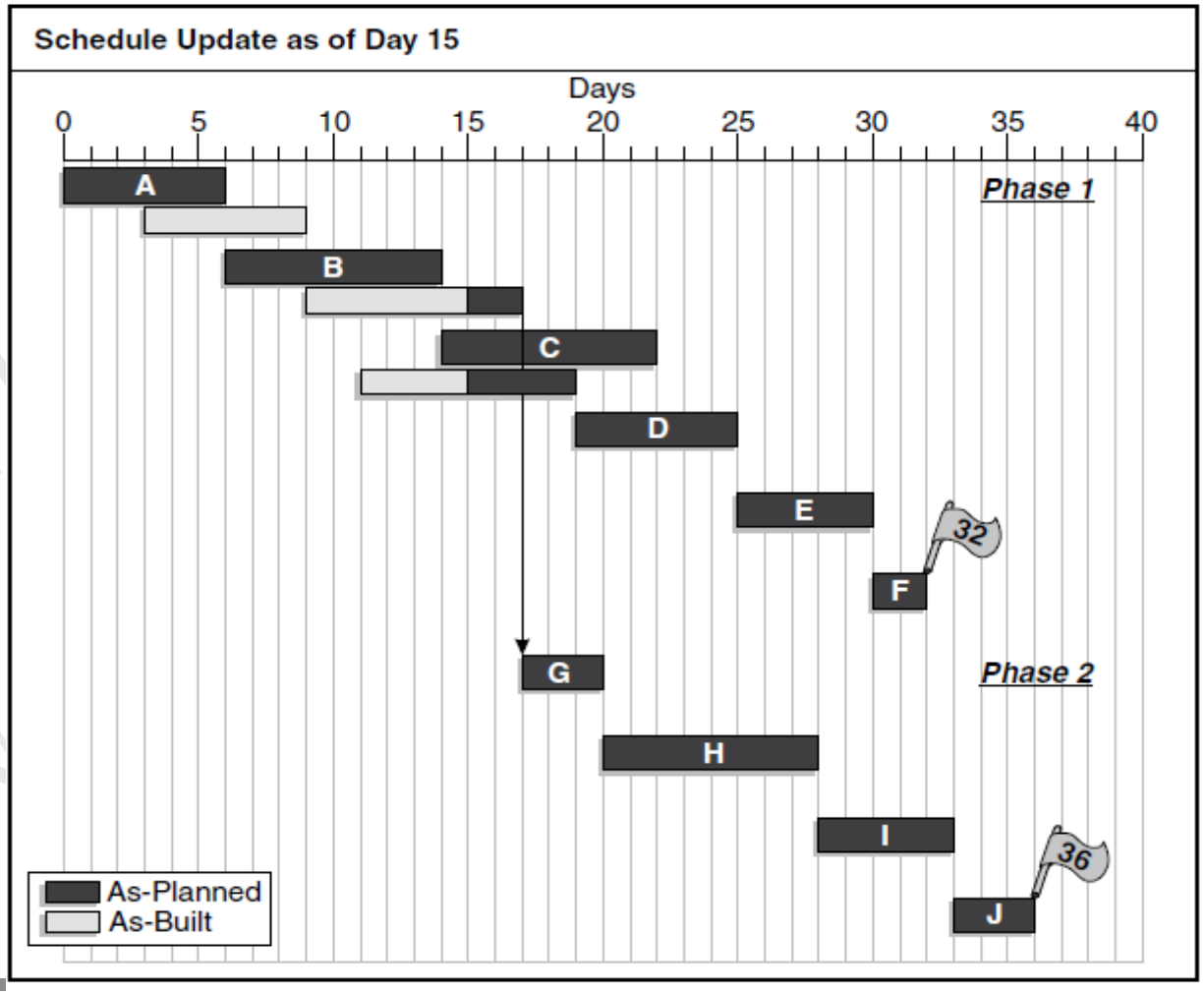
The overall conclusion is that the Project was delayed by five days, primarily because of the late finish of activity F.

This conclusion is erroneous.

Impacted as planned analysis – Weaknesses

❑ **Example:** What if the CPM approach is used?

- Schedule is updated as of **day 15**, the day the Contractor added activity J.
- The critical path has shifted to the **Phase 2 path** of activities, G through J due to the delay to **activity A**.
- The original critical path never becomes critical again and the project is delayed by **1 day** due to **activity J**.



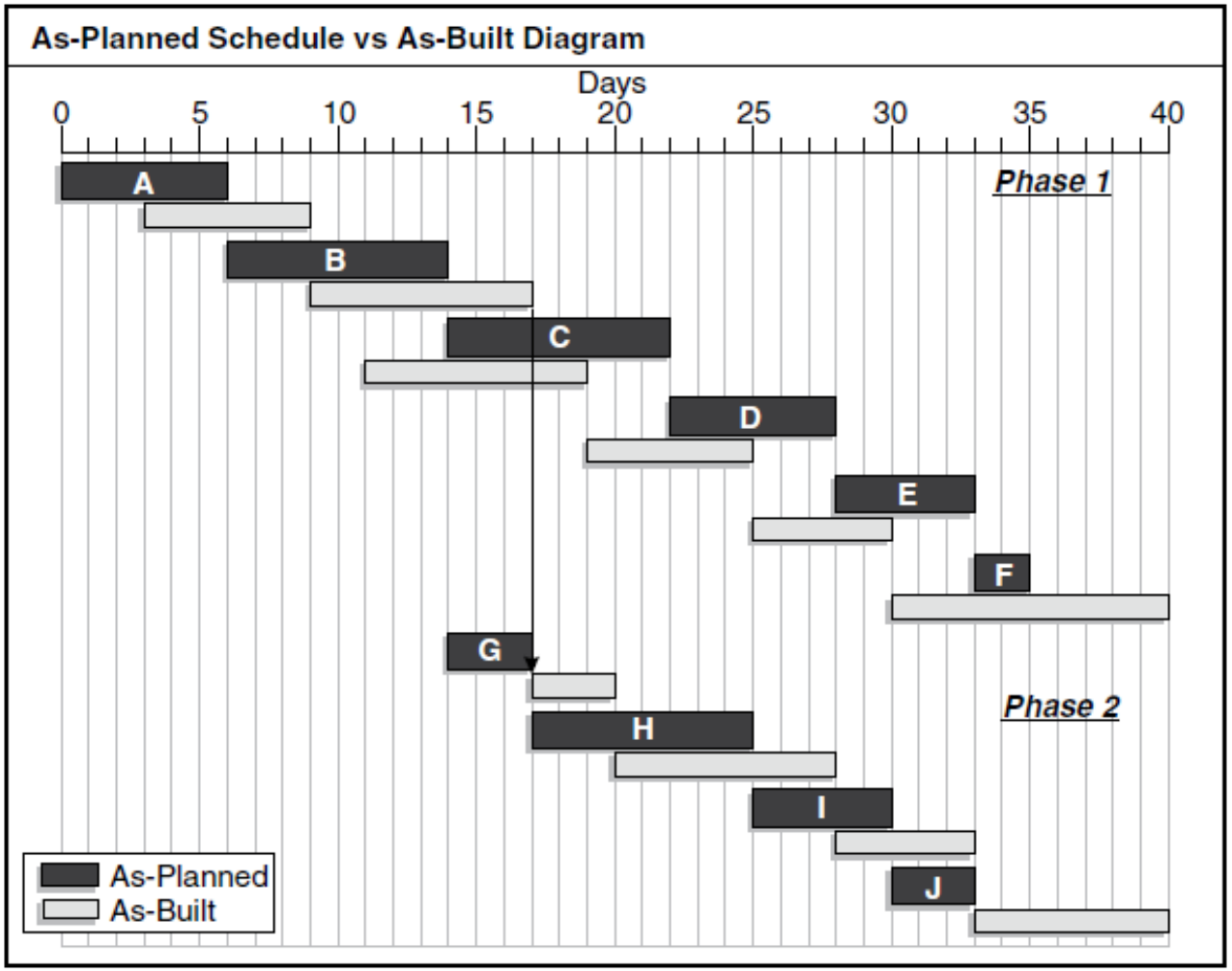
Impacted as planned analysis – Weaknesses

❑ **Example:** What if the CPM approach is used?

❖ Although

- ✓ Activity F took eight days longer.
- ✓ Activity J took four days longer.

Is it concurrent?



Impacted as planned analysis – Weaknesses

❑ **Example:** What if the CPM approach is used?

❖ **Impacted as-planned**

✓ Project was delayed **by five days**, primarily because of the **late finish of activity F**.

❖ **CPM approach using contemporaneous update:**

✓ **1 day** of delay due to **activity J**

✓ **4 days** of delay due to **concurrency**

Impacted as planned analysis – Weaknesses

❑ Example: Court decision

Mr. Maurer, appellant's expert, testified about the critical delays to the Project.... The analysis about the critical delays was based on appellant's original schedule, the schedule updates, the daily reports, Project correspondence, and the contract documents. Mr. Maurer described his analysis as a step-by-step process, beginning with the original schedule and proceeding chronologically through the Project, updating the sequence at intervals to see what happens as the Project progressed [(tr. 262) ASBCA No. 34, 645, 90–3 BCA ¶ 12, 173 (1990)].

Impacted as planned analysis – Weaknesses

❑ Example: Court decision

- ❖ The **judge's criticism** was that the **outcome of an impacted as-planned analysis**, because it **ignores** **everything other than the as-planned schedule.**

- ❖ It would **overstate the delay**, if any, associated with the **inserted delay**.
  - ✓ **Years of experience analyzing impacted as-planned analyses** have **confirmed** this judgment.

- ❖ **Employing** an **impacted as-planned analytical technique** is **flawed** and to be **avoided**.

Impacted as planned analysis – Weaknesses

❑ Example: Court decision

❖ Taken together, **these decisions** have an **important message**:

When analyzing delays, it is important to evaluate Project events relying on the documents in use on the Project at the time the delay occurred.

❖ In **summary**, the **only valid perspective** for the analyst is to adopt a **view of the Project contemporaneous** to the delay itself—**not from the beginning** of the Project or the **end of the Project**.

Impacted As-Planned (IAP)

(Conclusion)

Impacted as planned analysis – Conclusion

❑ Pros and Cons:

- ✓ **Simplest** and **low** in terms of **time** and **cost**
- ✓ **Only** requires **as-planned schedule** or original plan
- ✓ **Could be** used for **contemporaneous** schedule (**prospective delay impact**)
- × **Static analysis** (**prospective critical path**)
  - ❖ Assumes that **critical path never shifted**
- × It does **not consider actual progress** and **changes (hypothetical)**
- × **Subjective** because it is **one-sided:** typically **only** considers **owner delays** and does not consider contractor delays
- × **No consideration** of **true concurrent delays**
- × **Typically rejected** by the **courts**, **panels**, and **boards**

Impacted as planned analysis – Conclusion

❑ When to use?

1. Useful as **negotiation tools** when,

   for whatever reason, more in-depth and detailed methods of analysis are ruled out or **not available** to the parties.

2. If a **pre-agreed daily rate** for prolongation is available, accounting for **compensable delay** in a cumulative,

   combined and **forward-looking manner is also possible** using the **IAP modelling approach**.

Impacted as planned analysis – Conclusion

❑ When to use?

- ✓ The as-planned **logic** was accurate
- ✓ The as-planned **durations** were accurate
- ✓ The **delay events** were recorded

1. **As prospective analysis when:**
   - ✓ I usually **do not recommend** to use it, however
     - ➢ *If time and budget for the analysis is **very limited** and the **accuracy** of the outcome is **not that important***
2. **As a retrospective analysis**
   - ✓ I **do not recommend** to use it, unless
     - ➢ **Contractor followed** the as-planned logic or there is **no as-built data**
     - ➢ Both the owner and contractor **agree to use** this procedure

Time Impact Analysis (TIA)

Time impact analysis

❑ Definition

- ❖ **Invented immediately** after **CPM scheduling method** (maybe 1950) and developed in the early 1980s.
- ❖ **Two** forms:
  1. Contemporaneous analysis = **prospective** method
     - ✓ **Originally** developed for **prospective analysis**
  2. After-the-fact analysis = **retrospective** method
- ❖ They are very similar – **SCL prospective** and **AACE retrospective**
  - ✓ The **application** of this method in **post-contract dispute resolution** is deeply **questionable**.
    - o **Proponents** of **SCL Protocol** does **not appreciate this view**.

Time impact analysis

❑ Definition

❖ **TIA** is **more effective** as a **forward-looking tool** than as a **backward-looking** (or forensic) tool.

✓ This is partially **due to** the ability of the **Owner** to

1. **Forecast** and **respond** to the **results** of the analysis and
2. **Minimize** the **cost impacts** of a delay.

➢ **However**, **TIA** is an **acceptable** and **useable** tool for the **determination** of the **effects** of a **past delay** when employed for **forensic analysis**.

*The **longer the period** between the **delay** and the **approval of the TIA**, the **less useful** and **valid** the **TIA becomes**.*

Time impact analysis

❑ Definition

- ❖ This **TIA prospective practice** concerns itself with **time aspects**,

  not cost aspects of projects.

- ❖ The **time impact must** be **quantified prior** to **determining any cost** implications.
- ❖ **Linking time** and **cost** into **one analysis** implies that **time impacts** are a **function of costs**,

  which for the purposes of a prospective TIA is **not true**.

- ❖ **Separating time analysis** from **cost analysis** makes TIA inherently **easier** to accomplish and accept contractually.

Maintaining a set of timely, accepted, schedule updates is very important to the TIA success.

Time impact analysis

How to use (general steps)?

1. Identify **contemporaneous schedule** (**contemporaneously updated baseline schedule**)
2. Update the schedule, if necessary, to date of the change
   - If an **updated schedule** is not available,

     update the baseline schedule with **current progress information**.
3. Insert **delay event sub-networks (fragnet)** into a **update schedule**
4. **Recalculate CPM** using CPM programming software
5. **Determine** the **impact** **of** sub-networks (fragnet) have on the **predicted contract completion dates** shown **within** the **update schedule**

This is done on "Update Schedule"

Time impact analysis

❑ Example

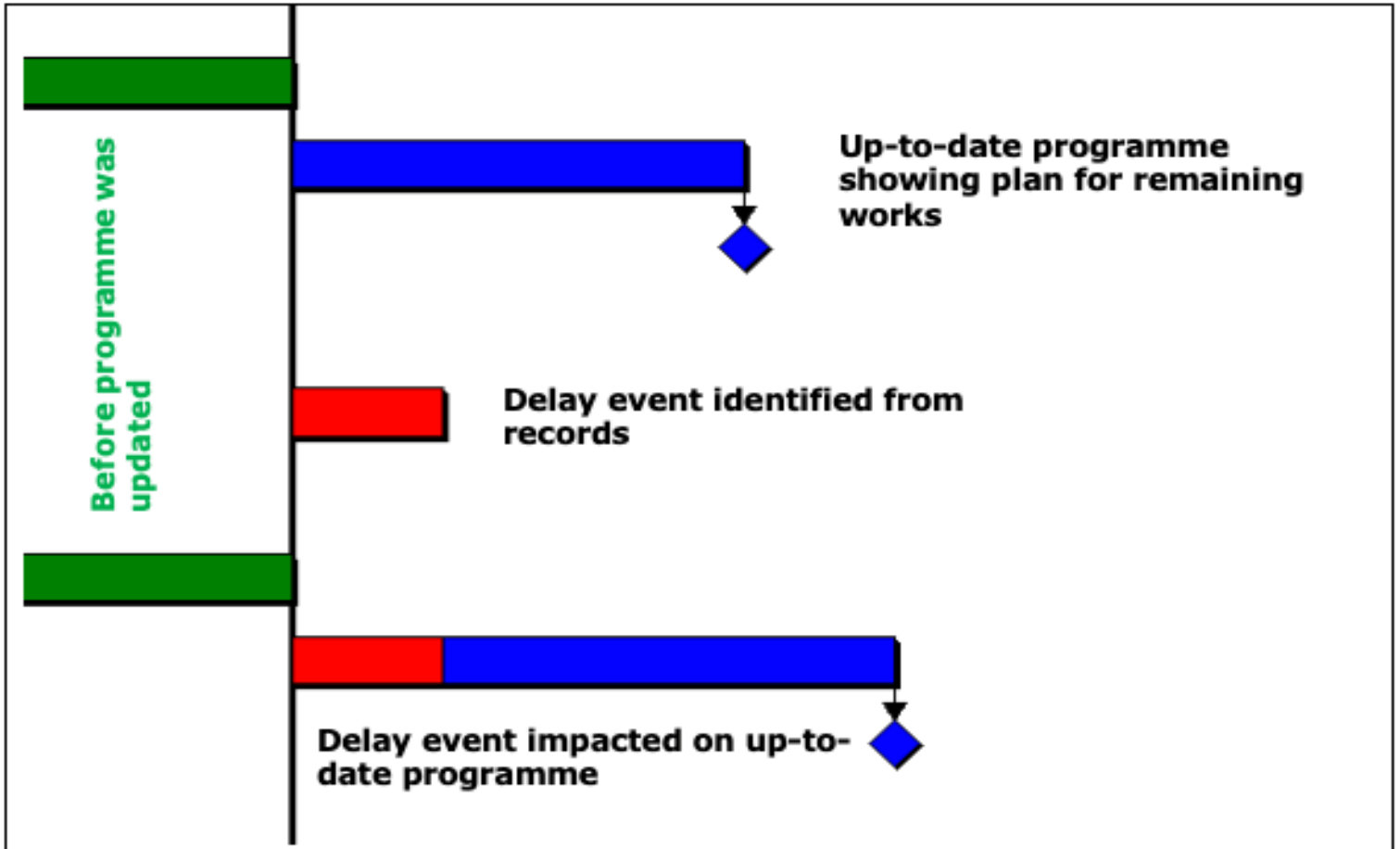
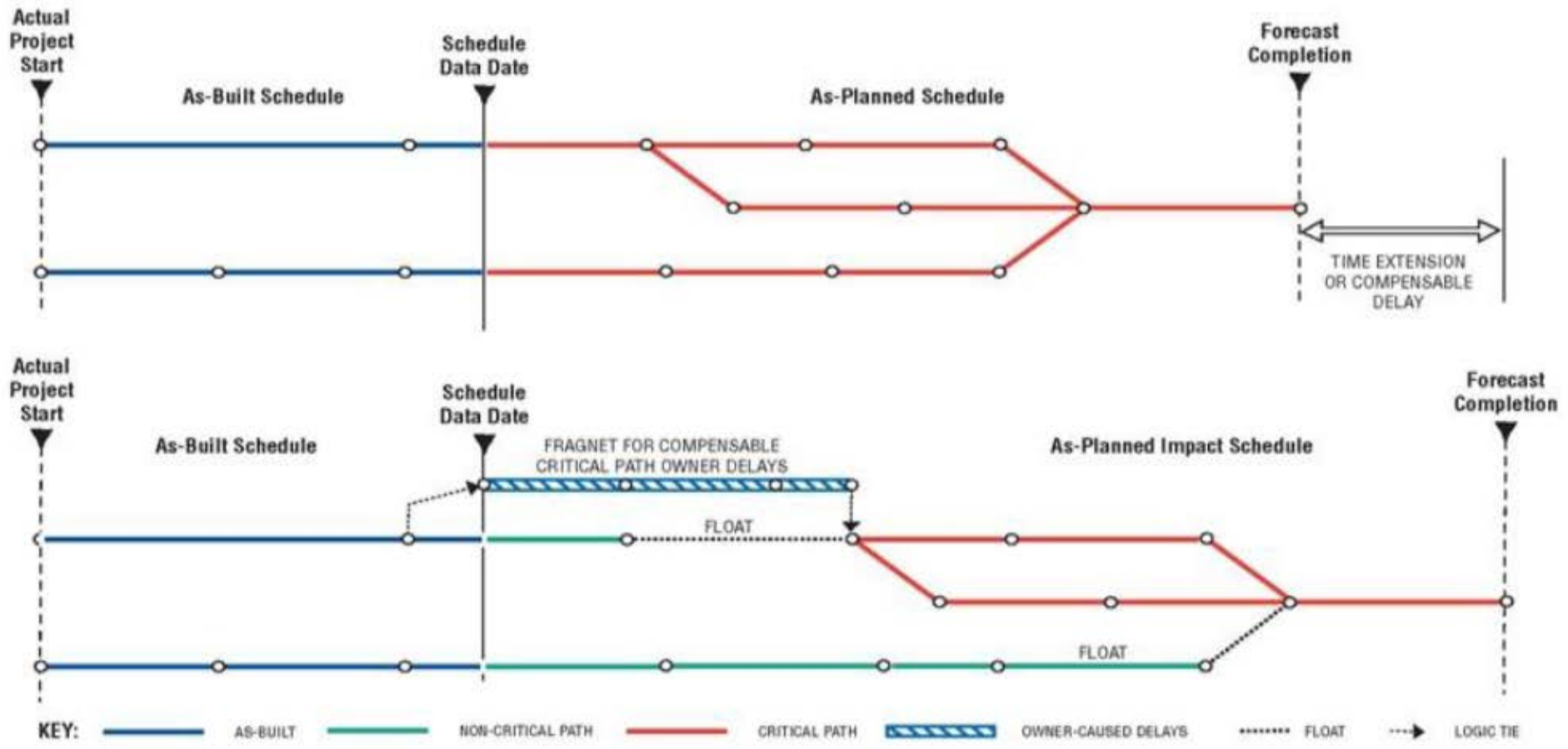


Diagram illustrating the Time Impact technique.

Time impact analysis

❑ Example



Time impact analysis

❑ Pros and cons

- ✓ It is **recommended** by **SCL CP 4**.
- ✓ **Dynamic analysis** (**contemporaneous critical path**)
- ✓ **Can** be used for both **contemporaneous** and **after-the-fact** schedule (**prospective and retrospective delay impact**)
  - × It is the most **time-consuming** and **costly** method when performed **forensically**
- ✓ It **considers actual progress** and **changes** (**not hypothetical**)
- ✓ **Subjectivity** is **eliminated** or **reduced** (**because of day to day analysis**)

Time impact analysis

❑ Pros and cons

× It **requires** a **detailed data** to analyze

× **High** in terms of **time** and **cost**

× **Requires** reliable periodic **schedule updates**

× **Typically** does **not consider concurrency** unless **functional theory** is considered

× **Subjective**, **when** only the delays of **one party are considered**, because the method cannot account for delays that are **not inserted**.

1. If **updated up** to the fragnet and
2. If **functional theory** is considered,

subjectivity **reduced**.

× **Susceptible to manipulation** when actual or as-built durations are compared to estimated durations

× **Extremely sensitive** to

1. Order of fragnet
2. Logic insertion

Time impact analysis

❑ When to use?

- ❖ When **project** is **ongoing** (prospective analysis)
- ❖ When **time** is really important for the project
- ❖ When there are
  1. **Logic linked baseline** schedule
  2. **Delay events** to model
  3. **Contemporaneous schedules** with process information

TIA is more or less acceptable and useable for the determination of delay impacts under some circumstances.

Let's see!

Time impact analysis

❑ When to use?

1. **More useable**

a) Frozen work plan

- If the **contractor** has **not** been **given** the **right** and is **not able** to **redeploy** his **work force** in order to **resume the work**, then the work plan is said to be **"frozen"** and **TIA** can be very **useable**.

b) Forward looking

- The **tendency** for parties to **wait and observe** the **actual durations** is in **conflict** with the **primary purpose** of **timely resolution in TIAs**.

c) Short duration of delay

- **TIAs** are **intended** to model delays of **less than one reporting period**.
- **If longer periods** are **considered**,
  then an **additional step** (**detailed later**) must be considered to **address** the **legal requirement** and **natural tendency** of the Contractor to **mitigate** any delays where the mitigation **does not** involve **additional costs**.

Time impact analysis

❑ When to use?

2. **Less useable**

a) The more your schedule update does not reflect actual conditions at the time of the delay

- The **longer time period** between the **updated schedule** and when the **delay started**.
  - ✓ It is because **more conditions** will have **changed** between times.

b) The less linear of the work plan

- **Work plans** with **more physical constraints** are **harder** than work plans with **resource constraints** that can be **allocated** to **mitigate**.

c) If more mitigation was accomplished during the delay

- This is **opposite** of a **"frozen" work plan**.
- The **more work** performed **"out-of-sequence,"**
  the **more effort** performed by either owner or contractor to **reduce** the **effects of a delay**, and
  the **less effective** a **TIA** due to **many changes**.

Time impact analysis

❑ When to use?

- ❖ The product of this method of analysis is a conclusion as to the **likely delay** of the **modelled delay events**

  on the programme/critical path that is m**ost reflective of the contemporaneous position** when the delay events arose.

- ❖ This method usually **does not capture** the **eventual actual delay** caused by the delay events as **subsequent project progress** is **not considered** ***(SCL Protocol).***

Time impact analysis

❑ Guide to the TIA

1. **List all identified delay** events in a table:
   - ❖ Duration
   - ❖ predecessors
   - ❖ successors
   - ❖ commencement date (when the event was first identified or first had an effect on the work).

موسسه مهندسی و مدیریت ساخت علوی پور (ACEMI)

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