MANAGEMENT OF VARIATIONS & CONSTRUCTION CLAIMS

PROJECT CONTROLS CONFERENCE

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MANAGEMENT OF VARIATIONS & CONSTRUCTION CLAIMS

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Introduction

- Purpose of session to discuss variations & claims
- Variations & claims inevitable, cannot be avoided
  - But can be managed & resolved on site
- Employers & contractors must learn fundamentals of contracts & claims
  - Rule No. 1 – Claimant must prove entitlement (liability), causation & damages (quantum) in order to recover
  - Rule No. 2 – Study & read the contract, many times
  - Rule No. 3 – Variations & claims must be dealt with promptly, on the project – not left to lawyers at end of job
Introduction

- Variations & claims a fact of life in construction
  - Engineering & construction an art, not science
  - Full of human judgement
- Claims a safety relief valve –
  - Necessary to provide equitable adjustments
- Contractors – Must learn how to pursue variations & claims properly
- Employers – Must know how to analyze & resolve variations & claims as promptly as possible
  - To avoid arbitration / litigation at end of project

Session outlines:

- Why & how claims develop
- What needed to make persuasive claim
- How to successfully defend against claims
- Offers ideas to help avoid, minimize & resolve claims in order to deter disputes
Some Definitions

- **Changed Site Condition** = Differing Site Condition, Unforeseeable Physical Conditions, Latent Conditions
- **Employer** = Owner
- **Dispute Adjudication Board** = Dispute Review Board
- **Program** = Schedule, Programme
- **Slack** = Float

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Some Definitions

- **Supplemental Conditions** = Particular Conditions
- **Tender** = Bid
- **Variation** = Change Order, Modification
- **Extension of Time (EOT)** = Time Extension
- **Time for Completion** = Completion Date
Variations

- **Definition of Variation**
  - “Action by employer or authorized representative directing contractor to construct some portion of the work in a manner different from that described in the plans & specifications for which the contactor or employer may be entitled to an adjustment in contract price &/or time”

- **Variations occur on all projects, needed to –**
  - Accommodate changing employer needs, deal with unforeseen issues, etc.

- **Contracts anticipate variations**
  - Almost all contracts have Variations clause
Variations

➤ Why need a Variations Clause?
  • Under Common Law one party has no right to demand anything other than that which was contracted for, without mutual agreement

➤ Clause allows employer to order variations without contractor agreement
  • Cannot afford to have variations “held hostage” until agreement reached with contractor

➤ If projects teams not resolve variations promptly more likely to end up with claims & disputes

Variations

➤ Variations –
  • Always involves cost (additive or deductive)
  • Frequently involves delay & time related damages
  • Often involves impact damages – lost productivity, idle labour & equipment, overtime work, disruption, etc.

➤ Employers & contractors must learn how to handle all elements of variations
Variations

- Variations a fact of life
- Variations beneficial for employer
  - Mechanism to resolve unforeseen issues
  - Way to respond to new, changed employer requirements
- **Problem**: Variations sole source, non-competitive procurement
  - Pricing frequently at issue
  - Perceived as low risk, very high profit!

Employer View of Variations
The Skiff

The Yacht
### Causes of Variations

- Unforeseen conditions
- Defective plans & specifications
- Scope variations by employers
  - Additional work, betterments, enhancements, preferences, deletion of work
- Value engineering
- Force majeure
- Delay or Acceleration

### Mitigation of Variations

- Thorough definition of work scope
  - Be able to identify “variation” vs. “design development”
- Adequate time for design
- Thorough site condition survey
- In-depth design review & coordination involving
  - Employer project staff
  - Subcontractors
  - Employer consultants
  - Construction team
  - Design team
  - Commissioning team
  - Employer operations team
  - Suppliers & vendors
- Variation management during EPC cycle
Opportunity for Influence

Level of Influence
- Major Influence
- Rapidly Decreasing Influence
- Low Influence

Scope Definition

Expenditures

Project Expeditures

Conceptual Analysis & R&D
Pre-Project Planning
Basic Data & Scoping
Project Authorization
Production Engineering
Procurement
Construction
Engineering Complete
Turnover & Start-up

Project Life Cycle

Identifying Variations

- Team knows scope of work
- Every employer direction, comment reviewed as potential variation
- Train project team –
  - If something appears to be variation, notify project management ASAP
  - Project management submit written notice to employer immediately
  - Do not proceed until employer responds!
  - If cannot wait – create “paper trail”
  - Track all costs, delays & impacts separately

Six W’s of Change
W – What do they want?
W – Within scope?
If the answer is “No”
W – When do they want it?
W – Will it impact cost?
W – Will it impact time?
W – Will it impact unchanged work?
Keeping Variations from Becoming Claims / Disputes

- Proper written notice
- Timely submittal of variation request with good supporting documentation in
  - Businesslike manner
  - In accordance with contract terms
- Prompt negotiations with employer
- Continue negotiations until settle
- Do not proceed with variation until variation order issued

CONTRACTOR CLAIMS vs EMPLOYERS
Contractor Claims

**Basic definition –**
- **Claim** – Written demand by one of contracting parties (employer or contractor) seeking, as a matter of legal right, additional time &/or money arising under or related to contract

**Fundamental rule of claims**
- Standard common law three part test
- Claimant (whether contractor or employer) must prove
  - Entitlement (liability)
  - Causation
  - Damages (quantum)
- Claimant **must** prove **all 3** to get first dollar and/or day!

Universe of Contractor Claims

- Employer Variations
- Constructive Variations
- Differing Site Conditions
- Suspension of Work
- Constructive Suspension of Work
- Force Majeure
- Delay
- Directed Acceleration
- Constructive Acceleration
- Termination for Convenience
- Termination for Default

1,000s of causes, **only 11** types of claims
Common Causes Of Claims

- Defective plans & specifications
- Differing Site Conditions
- Failure to promptly address problems & EOT requests
- Failure to negotiate EOTs & delay or impact costs with variations
- Inability to mitigate effects of delay
- Unusually severe weather
- Acts of government in sovereign capacity
- Labor strikes
- Acts of God (Force Majeure events)

International surveys show inadequate design & inadequate contract administration leading causes

Early Warning Signs of Claims

- Early warning signs of disputes include
  - Employer refusal to address & resolve variations
  - Employer refusal to address EOT requests
  - Employer failure to pay promptly
  - Employer reviews take too long, make too many comments
  - Disagreements over “scope of work” items
    - “The intent clearly was…”
  - Claim consultant, attorney writing letters, attending meetings
More Early Warning Signs

• Contractor told not to put things in writing
• Employer advises
  ✓ “We’ll take care of that at the end of the job”
• Change in employer’s management team members
• Major project “disruption & distraction”
  ✓ Inappropriate volume, frequency & timing of variations
• “Sea change” in employer attitude
  ✓ Stops addressing problems head-on (proactively)
• Cost escalation & overruns
• Constant resequencing of work

Contractor Claim Recognition Methods

➢ Four contractor claim recognition methods

• Event Method
  ✓ Every team member knows scope of work, knows what’s required & what’s not!
  ✓ When directed or required to do anything not in scope, give immediate notice!
• Cost Method / Cost Engineering Method
  ✓ Analyze cost reports by cost code, every month
  ✓ Note all overrun trends using Earned Value technique
  ✓ Analyze for causation
  ✓ If employer caused, give immediate notice!
**Contractor Claim Recognition Methods**

- **Time Method, Time Impact Analysis, Contemporaneous Period Analysis**
  - Analyze monthly program updates
  - Note any activity starting later than planned, taking longer than planned
  - Analyze for causation
  - If employer caused, give immediate notice!

- **Claim Prudency Review Method**
  - Periodically have external team review project records to identify potential variations & claims
  - Look for claim & risk issues that otherwise might remain undiscovered until end of job

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**Employer Early Claim Recognition**

- Changes in major subcontractors
- Problems with baseline program
- No, poor program updates
  - Milestones missed, **still on time!**
- Constant resequencing of work
- Contractor **not** negotiate variations in full
  - Only perform variance work on T&M basis
- Excessive RFIs / RFCs
- Subs complaining of lack of payment
Notice Issues

- **What is notice?**
  - Routine business communication to employer identifying issue which may have cost or time consequences for them

- **Why give notice?**
  - To protect employer
    - Safeguards their budget
  - To protect contractor
    - Safeguards their money
  - To help maintain control of project
    - Scope, time & cost
  - & because contract requires it!
Notice Issues – When Give Notice?

➤ When should contractor give notice?

- Contract tells them when to give notice – RTFC
  - Variations, Differing Site Conditions, Force Majeure, Suspension, Delay clauses, etc.
- Prepare contract summary at outset of project
  - Create list of all notice requirements
  - Give written list to everyone on project
  - Require project staff to post list on office wall
- Remind project team members …
  - “When in doubt, bring it to management attention so notice can be provided promptly!”

Notice Issues – Purpose?

➤ Purpose of notice is to …

- Provide opportunity for employer
  - To change their mind
  - To mitigate costs
  - To minimize time impact
  - To actively control destiny of their project
- Secondary benefit of notice
  - To preserve contractor’s right to request extra time & money, including cumulative impact, as appropriate
Why Notice Not Provided?

- **Failure to recognize problem**
  - Too close to trees to see forest

- **Embarrassment & assumption of guilt**
  - “It must be our fault…”
  - “We should have thought of…”

- **Don’t want to offend clients**
  - “This will really hurt our relationship with…”

- **Arrogance**
  - “We can handle situation without…”
  - “We don’t want to admit to late completion…”

- **Nice guy syndrome**
  - “Let’s help client out with this one by…”

- **Don’t want to be seen as “claims artist”**
  - “We don’t paper jobs like…”

- **Project team doesn’t understand contractual obligations…**
  - “We’ll wait until end of job before…”

- **Keep in mind –**
  - “Bad news delivered early is useful information. Bad news delivered late is a disaster!”
8 Ways to Give Effective Notice

- Written notice letters
- E-mail
- Verbal notice (if documented)
- Meeting, conference notes
- Monthly program updates
- Monthly progress reports
- Deviation notices
- Daily reports

Actual Notice

Constructive Notice

Risk of No Notice, Late Notice

- Owner surprised & angered
  - Relationship likely to be damaged
- Contractor’s legal position may be prejudiced or harmed for failure to comply with contract
- Provides employer with reason, ability & opportunity to deny request for time & money!
  - “No notice, no claim!”
Why Need Variations Clause?

- Under common law one party has **no right** to demand anything other than that which was contracted for, from other party, **without mutual agreement**
- Employers need flexibility to make variations to contract requirements
  - **Cannot** afford to have needed variations held hostage by contractor
  - Owners may **unilaterally** order variations to work
Directed Variation Claims – Definition

- Dispute over cost, time or impact of employer directed variation
- Arises from employer issued variation
- Dispute rarely over basis (merit or entitlement) of claim
- Dispute usually related to cost, time or impact of variation
  - Includes impact to unchanged work

Directed Variation Claims

- Most often arises when –
  - Contractors reserve their rights on employer issued variations, or
  - When variations performed on time & material basis
- To mitigate such claims –
  - Negotiate complete scope of work, all costs, all impacts & all delay issues related to variation
  - Add waiver of claim language to each variation order
  - Consult with legal counsel on waiver clause for variation orders
Directed Variation Claims

Examples of Disputed Costs

- Direct costs
- Unclear scope definition
- Idled equipment
- Unforeseen conditions
- Loss of productivity
- Wage rate impact

Directed Variation Claims – Entitlement

Elements of entitlement

- Employer directed variation
- Work added, deleted, changed, modified
- Cost records document direct cost damage
- Impact analysis documents indirect cost damage
  - Productivity analysis needed – Measured Mile Analysis
- Program analysis documents delay & disruption
  - Read contract – May specify delay analysis method
  - Typically, Time Impact Analysis
Directed Variation Claims – Analysis

- Scope of variation?
- Cost damages tied directly or indirectly to variation work?
- Variation sole proximate cause of delay?
- Impact stems solely from variation work?
**Constructive Variations**

- **Constructive variations –**
- **AKA – Disputed Variations**
  - Employer actions that have effect of requiring contractor to do more than required by contract & results in added time &/or cost
- **“Constructive” means –**
  - “...a variation implied in law by the conduct of the parties rather than their words ... a variation order that arises from the operation of law to avoid an injustice”

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**Constructive Variations**

- **Unintended or accidental variation**
  - Not result of employer issued variation order
- **Causes of constructive variations**
  - Contract language interpretation
  - Employer inspection actions
    - Overinspection
    - Underinspection (??)
  - Non-disclosure of information –
    - Unrevealed “superior knowledge” not revealed at time of tender
  - Constructive acceleration
Constructive Variations

• Defective Specifications
  ✓ **Errors** = specified, drawn incorrectly
  ✓ **Omissions** = not specified, not drawn
  ✓ **Ambiguous Specifications** = requirement can be read differently by different people
  ✓ **Conflicts** = drawn, specified differently
  ✓ **Impossibility** = physically impossible
  ✓ **Impracticability** = financially unreasonable

Constructive Variations – Ambiguous Requirements

➢ Contractor **not** have to prove interpretation right & employer’s wrong
➢ Contractor **not** have to prove interpretation more reasonable, more logical, better engineering
➢ Contractor need only show
  • More than one reasonable interpretation
  • Contractor **relied on** interpretation during tender process
  • & if do what employer wants, **will spend more cost or time**
Constructive Variations

- **Elements of claim**
  - Issue **not** foreseeable at time of tender
  - Work **exceeded** contract requirements
  - Notice **of** variation provided to employer
  - Variation actually **required** by employer
  - Additional cost or time actually incurred
  - Claim damages **mitigated**
  - If proven, contractor **entitled** to recover damages

Constructive Variation – Analysis

- **Issue foreseeable at time of tender?**
- **Work exceeded** contract requirements?
- **Notice** of variation provided?
- **Change required** by employer?
  - If **not**, contractor acted as volunteer?
- **Extra time &/or $$ incurred**
Why Need Differing Site Condition Clause?

- **Common law places all risk of differing site conditions on contractor**
  - Contractors may refuse to bid or include large contingencies to cover risk
- **Employer’s want to decrease contingency & pay only for conditions actually encountered**
- **DSC clause transfers all risk of differing site conditions to employers**
  - To decrease bid contingency & widen pool of bidders
Differing Site Conditions – Definition

- Latent (hidden) physical conditions encountered at site materially different from conditions indicated in contract documents or conditions normally encountered in work of this type in this area
  - Most often classified as –
    - **Type 1** – Conditions materially different than indicated in tender documents
    - **Type 2** – Unknown physical conditions, of unusual nature for type of work in area

Differing Site Conditions - Entitlement

- **Entitlement Basics**
  - Condition unforeseeable
  - After reasonable “sight” investigation
  - Physical condition
  - At site
  - Differing materially
  - Notice provided in timely manner
  - Employer has duty to investigate promptly
  - Employer may be obligated to give direction
  - If condition materially different & caused added cost &/or time, contractor entitled to recover
Differing Site Conditions – Type 1

➢ “Subsurface or latent conditions at the site differing materially from those indicated in the contract documents” *

* AIA, EJCDC, FIDIC, CMAA, FAR, ConsensusDOCS, most State DOT & many local government contracts contain similar language

Differing Site Conditions – Type 1

➢ Difference between represented & actual conditions
➢ Latent, not obvious at time of bid
➢ Conditions encountered must differ materially from conditions indicated
  • Contractor misled by contract documents
  • Conditions may be expressed or implied
  • Reliance on representations must be reasonable
➢ Conditions may be natural or manmade
Differing Site Conditions – Type 2

- “Unknown physical conditions at the site, of an unusual nature differing materially from those ordinarily encountered and generally recognized as inherent in work of the character provided for in this contract”*

* AIA, EJCDC, FIDIC, CMAA, FAR, ConsensusDOCS, most State DOT & many local government contracts contain similar language

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Differing Site Conditions – Type 2

- **Actual condition must be unusual & unforeseeable**
  - Not differ from representations – none given
- **But, differs from ordinary conditions**
  - In absence of pre-bid information contractor must anticipate some reasonable differences
- **Burden of proof much greater**
  - Requires analysis of bid documents, site review & analysis of job
- **Failure to make site visit fatal to claim**
Differing Site Conditions – Type 2

Differing Site Conditions

➢ **Conditions generally not included under DSC clause**
  - Severe weather, flooding, business, labour conditions
  - Not “physical” conditions existing at time of tender

➢ **Conditions sometimes included**
  - Variations in quantity
  - Conditions arising after contract award
    ✓ If employer had duty, ability to prevent, failed to do so
Differing Site Conditions – Analysis

- What conditions recognized at bid?
- What conditions actually encountered?
- Was there a material difference?
- Did material difference have cost & time impact?
- If “yes” --
  - Contractor met required elements of proof
  - Entitled to full equitable adjustment

Latent Conditions – Australia

- Traditionally, risk on contractor if
  - “...required to satisfy themselves as to nature & characteristics of the land both on the surface & below... “ (Dillingham Construction Pty Ltd v Downs)
- Now, AS-2124-1992, Clause 12 allows DSC recovery if contractor
  - Examined information provided
  - Made site inspection
  - Provided written notice
  - Documented additional cost &/or time
DIRECTED SUSPENSION OF WORK

Why Need a Suspension of Work Clause?

- Under common law one party has no ability to suspend (stop) work of another without constituting breach of contract
- Owner may need to suspend work for variety of reasons
- Does not want to be put into breach
- Clause provides trade off –
  - Owner may suspend work
  - Owner pays damages causes by suspension
Directed Suspension of Work

- Employer directive to stop all, some of work for limited period of time
  - May suspend work for own convenience
    - Not required to “justify” directive
  - If receive verbal directive, confirm in writing
  - Contractor may not cease working beyond order
- Mandates written return to work order to record end of suspension
  - If receive verbal directive, confirm in writing

Directed Suspension of Work – Definition

- Directed suspension compensable delay
  - But many contracts limit contractor recovery
    - “Contractor only entitled to justified & satisfactorily documented unavoidable expenses directly & reasonably incurred, resulting from such suspension & actually paid within the limits of applicable rates…”
- If contractor contributed in any way to project suspension, delay or interruption
  - Entitled to no time, no $$
Directed Suspension of Work – Reasons

- Suspension pending variation
- Suspension for DSC investigation
  - DSC clause a self-actuating stop work clause
- Suspension to allow parallel prime contractor to work in area
- Suspension due to environmental litigation
- Also, may have
  - Suspension due to safety violations
  - Suspension due to work quality disputes

Directed Suspension of Work – Entitlement

- Contractor must show employer directed work stoppage,
  - Not due to contractor actions
- Since compensable delay must show
  - Time & cost impacts & mitigation of damages
- Cost recovery may/may not be limited
  - May not be entitled to avoidable costs, profit
  - May only be entitled to “reasonable stand-by costs”
  - RTFC!
Directed Suspension Of Work – Analysis

- If employer directs suspension of work, no analysis of entitlement required
  - Need only document directive to suspend work
- Damage analysis -
  - Damages limited to suspended work?
  - Costs properly & separately tracked?
  - Equipment idled solely due to suspension?
  - Suspension costs reasonable & prudent?
  - Contractor mitigate damages per contract?
  - Notify employer of mitigation plans?

CONSTRUCTIVE SUSPENSION OF WORK
Constructive Suspension of Work

- **Action or inaction on part of employer that prevents contractor from proceeding with all or some of work**
  - Not directed or intended suspension of work
    - Accidental, unintended work stoppage

**Examples** –
- Delayed approval of submittals
- Delayed issuance of variations
- Delays in investigation of DSC
- Site or ROW unavailability
- Delayed delivery of OFCI items
When Does Employer Action Become Constructive Suspension?

- When employer action “unreasonable”
- Situations typically grow out of known, predictable delays
- **Examples** – Contract stipulates
  - 30 days to respond to submittals
  - Employer to investigate alleged DSC’s “promptly”
- When employer action exceeds norm, deemed unreasonable
- Becomes constructive suspension of work

Difference Between Delay & Constructive Suspension

- **Constructive suspension** generally grows from predictable, foreseeable delay situations with standard to measure against
  - **Example** – Delayed approval of submittals
- **Delay** generally grows from unknown, unpredictable events, unanticipated at time of contract award
  - **Example** – DSC’s, variations to work scope, force majeure events
**Constructive Suspension of Work - Entitlement**

- To recover, constructive suspension must be
  - Unforeseeable & unreasonable
  - Reasonably under control of employer or someone for whom employer is responsible
  - Timely written notice provided to employer
  - Suspension must result in impact to contractor’s time &/or cost
  - If proven, contractor entitled to recover of damages

**Constructive Suspension of Work – Analysis**

- What caused constructive suspension?
- Did cause violate terms of contract?
- Cause foreseeable during tender process?
- Cause under control of employer?
- Work suspended or simply disrupted?
  - Former = suspension  Latter = variation impact
- Suspension impact work & program?
  - If so, how?
FORCE MAJEURE

- Unforeseeable events caused by third party or act of God that contractor could not avoid or control & which causes project delay
- May be natural or manmade – Examples
  - Tornadoes: Acts of war, terrorism
  - Earthquakes: Acts of government as sovereign
  - Tsunamis: Civil strife
  - Floods: Labor actions
  - Wildfires: Variations in law
Force Majeure

- **Contracts typically provide list of events**
  - Examples, **not** all inclusive lists unless contract states

- **To recover, contractor must**
  - Provide prompt written notice
  - Demonstrate
    - Event unforeseeable
    - Beyond their control
    - Caused substantial impact to work

- **Contracts typically provide excusable, non-compensable delay – time, no money**

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Force Majeure – Entitlement

- **To recover, must provide written notice**
  - "The Contractor shall provide prompt written notice…"
  - "… notice shall be given **within 14 days** after the Party became aware, or should have become aware of the event or circumstance constituting Force Majeure…"
  - "… must provide written notice **same day** as force majeure event commences…"

- **Must demonstrate**
  - Event unforeseeable & **not** anticipated by reasonable, prudent contractor
  - Beyond control of contractor
  - Project impacted
Force Majeure – Analysis

- **Substantial impact** –
  - Must document program impact separately from other events
- **Beyond control** – Fairly easily shown
- **Unforeseeability** – may be difficult to show
  - Events unpredictable in one area common in another

Force Majeure – Damages

- **Recoverable damages defined by contract**
- **Time almost always recoverable**
  - May have to show critical path impact & mitigation
- **Cost (including delay costs) only recoverable**
  - If allowed by contract
  - May be restricted to date of notice, not awareness of event
  - Damages may have “deductible” amount
- **RTFC!**
Delay – What Is It, Really?

- Depends on contract terms
- “Delay” generally defined as
  - Interference with progress of critical path activity, or
  - Interference with progress of activity that consumes activity’s float (total float) & pushes activity onto critical path
  - & causes milestone date(s) or end date of project to be late
Delay – What Is It?

- Must look to contract language
  - Delay may = “impact to critical path”
  - Delay may = “delayed early completion”
  - Delay may = “float consumption”
  - Delay may = “start later than planned”
  - Delay may = “disruption leading to impacts”
- Delay most often not defined term
- Frequently in eye of beholder

Some Definitions

- Critical Path
  - Path of longest duration of continuous & dependent work activities through program network – Why?
    - Because, it’s the minimum amount of time required to build project
  - “Total Float” could be “+”, “0” or even “-”
    - Based on float concept, critical path often defined as
      - “path with least amount of float”
      - “path with greatest amount of negative float”
Some Definitions

**Float (AKA – Slack)**

- **Free Float**
  - Measure of activity’s ability to have its performance extended or delayed *without* affecting early start date of succeeding activity

- **Total Float**
  - Measure of activity’s ability to have its performance extended or delayed *without* affecting critical path or project end date

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Delay Claims – General

- Delay common problem on work sites
- One of most difficult problems to resolve
- Important to clearly identify causation
  - Different causes = Different outcomes
- & delay often results in disruption
  - Productivity loss
  - Cumulative impacts
Delay Claims – Typical Causes of Delay

- **Only 4 causes of delay in contracts**
  - **Employer**
    - Including “employer’s agents” – designers, CM’s, etc.
    - Or, events for which employer assumed responsibility (i.e., DSC)
  - **Contractor**
    - Including subs, suppliers, vendors, etc.
  - **Neither (Force Majeure Delay)**
    - Unforeseen events over which there is no control
  - **Both (Concurrent Delay)**
    - Employer & contractor both responsible for same delay or independent delays affecting same activity

Float Ownership Issues

- **Only three choices available**
  - **Employer owned**
    - Often results in phony programs
    - Schedules with no float (CP + 10 or more sub-CPs)
    - Employer at risk
  - **Contractor owned**
    - No need to prove critical path delay
    - All delay considered recoverable
Float Ownership Issues

- **Jointly owned**
  - Neither party owns float – float an expiring resource, jointly owned, used on first come, first served basis
  - Generally, to get time extension, contractor must show all float consumed & critical path delayed

- **If contract silent on float ownership issue, at common law, jointly owned float most likely outcome**

Delay Claims – Categories of Delay?

- **Three general categories of delay when performing program delay analysis**
  - Independent Delays
  - Serial Delays
  - Concurrent Delays
Independent Delays

- Delays occurring in isolation of one another
- Not result of previous delay(s)
- Effect of independent delay more easily calculated
- But, may be start of a serial delay

QUESTION: Does the end date of the program move?
Serial Delays

- Delay(s) arising as result of earlier delay(s) in work
- Example –
  * Design error discovered – as a result
    - Work in field delayed
    - Severe weather occurred when work restarted
    - Delayed work restarted but later impacted by areawide labour strike
- Independent delay is design error
  * Everything else serial delay

QUESTION: Does the end date of the program move?
Concurrent Delay

- **Two or more** delaying events occur
  - Caused by same or different parties
- **Either** event causes delay to end date
  - Schedule delay results if **either** event arises
  - Delays **not** have to be of equal duration
  - But, **must** overlap to some extent
- **Concurrent delay** may also occur if events fall on parallel critical path activities

Concurrent Delay – Realistic

**QUESTION:** Does delay cause end date of program to move?

**QUESTION:** Does delay cause end date of program to move?
Delay Claims – Types of Delay

- **Basic types of delay**
  - Inexcusable delay
  - Excusable delay
  - Compensable delay
  - Concurrent delay

Contracts typically address

Owners often assert

- Float Consumption
- Pacing delay
- Early Completion Delay

Courts recognize

Delay Claims – Inexcusable Delay

- **Typically** – Delay caused by contractor or one of subs, suppliers or vendors, at any tier
  - & end date of program impacted

- **Examples**
  - Failure to properly man project, coordinate equipment, material deliveries, etc.
  - Failure to provide submittals in timely manner
  - Project mismanagement

- **Or, delay foreseeable at time of bid**
Delay Claims – Inexcusable Delay

- Typically results in...
  - No time extension
  - No extended overhead costs
  - Imposition of late completion damages or acceleration by contractor to make up lost time

- Rationale...
  - Contractor caused delay
  - Contractor pays price

Delay Claims – Excusable Delay

- Typically – Unforeseeable, 3rd party caused delay or delay beyond control & without fault or negligence of contractor
  - Including agents, subs, suppliers & vendors at any tier
  - & end date of program impacted

- Examples
  - Acts of God
  - Acts of Government
  - Fires
  - Acts of War
  - Strikes
  - Freight Embargoes
Delay Claims – Excusable Delay

- Typically results in...
  - Time extension
  - No extended overhead costs
  - Forgiveness of late completion damages for time allowed

- Rationale...
  - Neither party caused delay
  - Neither party should benefit from delay
  - Neither party should be harmed by delay

- But, watch for exculpatory clauses

---

Delay Claims – Excusable Delay

- How handle excusable delay?
- Depends on form of contract...
  - Calendar Day Contract
    - Issue variation with extra days & adjust time of completion but no delay damages
  - Working Day Contract
    - Do not count delay days in monthly statement of working days report
  - Fixed Date Contract
    - Contractor at risk as most do not provide time extensions for excusable delays
Delay Claims – Compensable Delay

- **Typically** – Unforeseeable delay caused by employer or agent(s) or delay caused by situation for which employer has assumed contractual liability
  - & end date of program impacted

- **Examples**…
  - Variations  Work Suspensions
  - Delayed Responses  Site Conditions
  - Parallel Prime Delays

Delay Claims – Compensable Delay

- **Typically results in**…
  - Time extension
  - Extended overhead costs
  - Perhaps, profit (fee) & bond costs also

- **Rationale**…
  - Employer cannot harm contractor with impunity
  - Unless contract provides for such result
Delay Claims – Compensable Delay

- **Watch for No Damage for Delay clauses**
  - May preclude recovery of delay costs
- **Australian law now acknowledging similar exceptions to such clauses as recognized in U.S. Courts**
- **Additionally, Australian concept of “apportionment” may reduce impact of NDFD clause**

No Damage For Delay – Exceptions

- **Must be unambiguous to be enforceable**
  - No other clause allows recovery of delay
- **Employer waived clause by previous action**
  - Previously issued variation with delay damages
- **Delay not within contemplation of parties**
  - Employer failure to provide required easements
- **Delay amounting to contract abandonment**
  - Work suspension for 90 days or Force Majeure event exceeding 120 days in duration
No Damage For Delay – Exceptions

- **Delay not covered by clause**
  - If clause lists events where clause applies but event **not** included in list
- **Delay caused by fraud, bad faith of owner**
  - Owner knowingly provided inoperative equipment
- **Delay caused by employer active interference**
  - Employer repeated failure to make timely payments
- **Clause barred by public policy, statutes**

Delay Claims – Concurrent Delay

- **Typically** –
  - If program has **parallel critical paths** & concurrent delay within same timeframe
  - If program has **single critical path** & multiple delays within same timeframe then may have concurrent delay
    - If, end date of program impacted by each event independently
    - **Test** = Put each event in program on own to see if each causes program end date to move
Delay Claims – Concurrent Delay

➢ To be concurrent delays
  • Must overlap
  • Must be “inextricably intertwined”

➢ Examples…
  • Variation at same time late equipment delivery
  • Weather impact at same time differing site condition encountered
  • Late response to drawings at same time labour strike occurs

Delay Claims – Concurrent Delay – U.S.

➢ Typical results in U.S. …
  • Contractor & employer delay (Inexcusable vs. Compensable)
    ✓ “No Harm, No Foul” rule generally applied
    ✓ Result: Time, no costs, no late completion damages
  • Multiple contractor delays (All Inexcusable)
    ✓ Result: No time, no costs, contractor pays late completion damages or makes up lost time
Delay Claims – Concurrent Delay

- Multiple employer delays (All Compensable)
  - Result: Time extension, extended overhead costs, no late completion damages
  - But, only day for day delay
- One delay compensable (variation or DSC) while other excusable (weather or strike)
  - Result: Time extension, no costs, no late completion damages

Delay Claims – Concurrent Delay – English Law

➢ Typical ways of dealing with concurrent delay...

- Devlin Approach –
  - If two causes of delay operate together & one a breach of contract, party responsible for breach liable for loss
- Dominant Cause Approach –
  - If two causes effective, dominant cause will be deciding factor
Delay Claims – Concurrent Delay – English Law

- **Burden of Proof Approach** –
  - If two causes of delay operate together & claimant is in breach of contract, it is for claimant to prove loss was caused otherwise than by its breach

- **Malmaison Approach** –
  - If two concurrent causes of delay, one of which is relevant event & other not, contractor entitled to EOT for period of the relevant event not withstanding concurrent delay

Delay Claims – Float Consumption

- **Typically** – Activities start or complete later than planned
  - But, end date of program not impacted
- **AKA = Non-controlling delay**
- **Typically results in...**
  - No time extension
  - No extended overhead costs
  - However, impact or mitigation costs may be recoverable
    - If causal connection can be demonstrated
Delay Claims – Float Consumption

- **Rationale…**
  - Project **not** delayed
  - **No** time related costs incurred
  - But, impact & mitigation costs allowable
    - If impact brought about by employer caused event
    - If cause & effect can be documented & quantified
    - Or, if contract requires contractor to mitigate all delays, critical path or not

Delay Claims – Pacing Delay

- **Typically** – Deceleration by one party in reaction to actual or projected delay brought about by delay of other party
  - Project end date **may** or **may not** be impacted

- **Examples…**
  - OFCI late, contractor or one of contractor’s contractors demobilizes part of crew
  - Parallel prime late, contractor or one of contractor’s contractors slows down work
Delay Claims – Pacing Delay

- Typically results in ... an argument!
  - In U.S. contractors have legal right to slow down if don’t violate contract or harm employer’s position
  - Not required to maintain original program in face of known employer delay
  - No need to “hurry up & wait”
  - What is not clear is...
    - Whether compensation flows from “business decision”

Rationale...
- One party causes delay while other mitigates own damages – but is it compensable?

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### Delay Claims – Pacing Delays

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- Owner Delay
- Pacing Delay?
Delay Claims – Pacing Delay

➢ Owners argue pacing delay amounts to
  • Contractor imposed impact
  • Concurrent delay, or
  • Float consumption

➢ Risk:
  • Contractor paces employer delay, employer overcomes delay & contractor’s pacing becomes critical path
  • Typical delay analysis treats pacing delay as reducing time between actual completion & when job would have finished “but for” employer delay

Delay Claims – Delayed Early Completion

➢ Project not have to complete late (beyond contract time) to incur delay
  • May finish late & claim delay
  • May finish on time & claim delay
  • May finish early & claim delay

➢ Contractor entitled to finish work early
  • Especially true if contract has an early completion bonus

➢ Delays which impact early completion may be recoverable – Delayed Early Completion
Delay Claims – Delayed Early Completion

- **Typically** – Project on track to accomplish completion earlier than required under contract
  - Early completion delayed by employer or event(s) for which employer has assumed liability & not impacted by contractor or subcontractor
  - & end date of current program impacted
- **Typically results in...**
  - Time extension
  - Extended overhead costs
  - May result in recovery of early completion bonus, if contract allows

Delay Claims – Delayed Early Completion

- **Rationale ...**
  - Contractor controls “means & methods”
  - Contractor entitled to complete work early
  - Contractor entitled to recover if early completion impacted
- **But, watch for**
  - **No Damage for Delay clauses**
    - Try to deny recovery of delay costs
  - **Float Ownership clauses**
    - May deny time extensions & delay damages until all float consumed
  - **Delay Mitigation clauses**
Delay Claim – Delayed Early Completion

➢ What must contractor show to recover?
  • As-planned early completion program
    ✓ Or, updated program showing early completion
  • Followed program
    ✓ At least until delaying events or outside forces overtook plan
  • Project on track to complete work early
  • Requested time extension & employer denial

Delayed Early Completion – Australia

➢ Is contractor entitled to complete early?
  • Yes, if employer obligated to facilitate early completion
  • Depends on terms of contract
➢ Contractor entitled to EOT where early completion delayed?
  • Yes, depending on which party has benefit of “float” under contract
Delay Claims – Analysis

- Delay clause generally allocates risk of delay to party causing delay
- Notice requirement
  - Notice of delay critical to preserving rights
- Impact of program & scheduling specification on delay analysis
  - What does scheduling specification require?
  - What does program & delay analysis document?

Delay Claims – Analysis

- General starting point – Examine
  - As-Planned or Baseline Program
  - All program Updates
  - As-Built Program
- Determine which activities controlled delay or program impact & slippage
  - Analyze for causation
  - Analyze for notice
  - Document cause & effect relationship
To Win A Delay Claim – Must Prove

Event(s) occur -- delays or will delay the project

Provide written, timely notice of delay

Document delay unforeseeable not caused by Contractor or subs

Contemporaneously document all time, cost & impacts separately

Time extension request properly filed

Demonstrate delay event sole cause of damage

Choose appropriate Program delay analysis technique to quantify delay

Capture contemporaneous costs to document delay cost

So, what’s an “appropriate” delay analysis technique?

Delay Claims – Delay Analysis Techniques

- Several delay analysis techniques available
- All techniques work, but --
  - Some “frowned on” in litigation
    - May still be successful in negotiation, mediation or arbitration forums
  - While all techniques work, some better suited for different purposes
    - Concurrency analysis, excusable delay vs. productivity impacts, etc.
- Project must select most effective technique based upon documentation & forum
Delay Analysis Techniques

- Complicated by the fact that no "standard practice" in the industry for program delay analysis.
- Two recommended practices:
  - **U.S.** – AACE International’s “Recommended Practice 29R03 – Forensic Schedule Analysis”
    - [www.aacei.org/Professional Resources/Recommended Practices](http://www.aacei.org/Professional Resources/Recommended Practices)
  - **U.K.** – Society of Construction Law’s “Protocol for Determining Extensions of Time for Delay & Disruption”
    - [www.scl.org.uk](http://www.scl.org.uk) – SCL Delay & Disruption Protocol

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Delay Analysis Techniques

- **2 types of program delay analysis techniques**
  - **Prospective**
    - Forward looking analysis
    - Frequently called “Time Impact Analysis” (TIA) or “Time Impact Evaluation” (TIE)
    - Example: Variation cost proposal requesting an EOT
  - **Retrospective**
    - Backward looking analysis
    - Example: Claim submittal done after event has passed
Prospective Delay Analysis – Single Fragnet TIA

Retrospective Delay Analyses

- Retrospective delay analyses used to justify claimed time extensions
  - Backward looking or hindsight forensic scheduling
- 4 basic types of retrospective program analysis accepted in Australia & U.S.
  - As-Planned vs. As-Built
  - Impacted As-Planned
  - Collapsed As-Built
  - Schedule Window Analysis
As-Planned vs. As-Built Delay Analysis

- **AKA** = Total Time Schedules
- **Methodology**
  - Recover or recreate as-planned program
  - Recover or create as-built program
  - Calculate difference between end dates
    - Differential = Delay owed by other side
  - Analyze & identify events, caused by other side, to “explain” differing end dates
Impacted As-Planned Delay Analysis

- **AKA = As-Planned + Delay Schedules**

**Methodology**
- Recover or recreate as-planned program
- Determine which delay event(s) (caused by other side) drove delay(s)
- Add delay event(s) to as-planned program
  - Maximize compensable vs. excusable delay
- Recalculate program duration
- Determine time extension & compensation owed & liquidated damages, if any
  - May need to “balance” analysis (to match facts & alleviate concurrency)

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<td><strong>Impacted As-Planned Durations Due to Owner Delays</strong></td>
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**Delay**
- 1/2 Mo.
- 1/2 Mo.
- 1/2 Mo.
- 1/2 Mo.

Tot. Delays = 2 Mos
### Impacted As-Planned Delay Analysis

- **RISK when using this technique**
  - Not arise when using other delay analysis techniques

- **What is risk?**
  - Owner can turn program analysis around using same technique
  - Insert only contractor’s delays into as-planned program & recalculate program
  - May end up with entirely different result?

### Collapsed As-Built Delay Analysis

- **AKA -- “But For” Schedules**
- **Methodology**
  - Recover or create as-built program
  - Identify all employer caused delays on program
  - “Remove” all employer caused delays
    - Leave activities, zero out durations, maintain logic
  - Recalculate program to determine new completion date
    - “But for” actions of employer, contractor would have finished no later than this date
  - Calculate delay & late completion damages
Schedule Window Analysis

**Methodology**

- Recover or recreate as-planned program
  - Adjust, if necessary, to reflect original plan
- Select “meaningful periods” for analysis
- Enter actual progress for first period into as-planned, baseline program
- Recalculate program, determine if delay resulted
  - If so, analyze delay for causation
  - Assign responsibility for delay
  - Track on Delay Responsibility Matrix

Delay Responsibility Matrix

<table>
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<tr>
<th>Schedule Update</th>
<th>Compl. Date</th>
<th>Owner Delay</th>
<th>Contr. Delay</th>
<th>3rd Party Delay</th>
<th>Concrnt. Delay</th>
<th>Total Delay</th>
<th>New Compl. Date</th>
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<td>06/30/04</td>
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<tr>
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<td>07/26/04</td>
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Schedule Window Analysis

• Copy recalculated program as “baseline” for next period to be analyzed
• Repeat process as many times as necessary to complete program analysis

➢ Methodology also referred to as
• Time Impact Analysis (VA & NASA)
• Contemporaneous Period Analysis (Schumacher)
• Snapshot Methodology (USACOE)
• Period Analysis (Ramey)

➢ Regardless of nomenclature
• All function in same basic manner

Delay Claims – Liquidated Damages

➢ “Liquidated” = Pre-determined, fixed in advance
➢ Liquidated Damages (LD’s)
  • Estimate of damages employer likely to incur if project completed late
    ✓ As known at time of bidding

➢ To be enforceable
  • LD’s must be based on estimate of damages if job completed late

➢ LD’s are enforceable
  • Provided not a “penalty”
Delay Claims – Liquidated Damages

- **Liquidated damages**
  - Do **not** have to be proven to be collected
  - Do **not** have to be “offset” by early completion bonus to be collected
  - Do **not** have to reflect actual damages incurred to be collected

- **Australian & U.S. law on LDs very similar**
Directed Acceleration Claims – Definition

➢ Employer direction to complete work
  • Earlier than programmed
  • Earlier than allowed under contract

➢ Employer’s authority to direct acceleration
  • Most often in Variation clause
  • Sometimes in Delay clause
  • Delay, Variations, Force Majeure clauses may have “delay mitigation” requirement

Directed Acceleration Claims – General

➢ Acceleration order should be written

➢ Why?
  • It’s a Variation!

➢ If contractor receives verbal directive
  • Confirm directive in writing
  • Get employer to “ratify” directive
    ✓ In writing or by non-response
Deceleration Directives – General

- Deceleration also possible
- What is deceleration?
  - Employer direction to slow down work
- Authority
  - Variations clause
  - If can accelerate “…only logical employer can decelerate…”
- Why do it?
  - Make room for parallel prime contractors
  - Avoid conflict with other projects

Directed Acceleration Claims – Reasons

- Complete work earlier for employer convenience
  - Make room for other contractors
  - Start other projects
  - Cash flow reasons, project economics
- Or, “buy back”
  - Employer caused delays
  - Avoid delay damages to parallel prime contractors
- Contractor may also accelerate or decelerate subcontractors & suppliers, if needed
Directed Acceleration Claims – Entitlement

➢ Document employer direction to accelerate or decelerate
  • Once direction documented, merit established

➢ Track damages & impacts separately
  • Document damages directly & indirectly related to acceleration/deceleration directive

➢ If looking to “buy back” delay
  • Compare acceleration to delay costs (or LD’s)
  • Look for “least cost” alternative

Directed Acceleration Claims – Analysis

➢ Document acceleration/deceleration directive(s)
  • Establish merit of claim

➢ Ascertain & collect all damages

➢ Are damages logical?
  • Are damages reasonably related, directly or indirectly, to acceleration/deceleration directive?
  • Don’t overlook impact costs
Constructive Acceleration

- Employer action or failure to act that inadvertently causes contractor to complete work earlier than required or should have been required

- Concept
  - If employer refuses to grant EOT & “threatens” late completion damages or default termination
  - Contractor must taken action to “protect themselves”
Constructive Acceleration

- **Examples**
  - Variations issued without proper time extensions
  - Failure to grant time extensions until end of project
  - Refusal to grant time extensions until contractor "needs more time"
- **Employers frequently reluctant to grant time extensions early in project**
  - "What if contractor makes up the time later?"

Constructive Acceleration – Entitlement

- **Excusable** delay encountered
- **Notice** of delay & **EOT requested**
- Employer **denies** all, part of time owed
  - & silence by employer = same as denial
- Contractor **required** to complete work "on time"
  - "Threats" count
- **Notice of constructive acceleration submitted**
  - No submittal, potential deal killer
- **Additional costs** actually incurred
- **Equitable adjustment owed**
Constructive Acceleration – Claim Analysis

- Delay encountered & written notice given?
- EOT properly requested?
- Properly responded to by employer?
- Contractor “required” to accelerate?
- Contractor gave notice of constructive acceleration?
- Acceleration damages recorded separately?
  - Overtime work
  - Additional crews or equipment
  - Ripple & productivity impacts

Constructive Acceleration – Australia

- Australian law not recognize term
- Courts recognize legal concept in *Perini Pacific*
  - CA refused to award EOTs
  - Contractor accelerated & sought damages
  - Court rule employer had “implied duty” to ensure CA was properly administering contract
  - Concluded employer not fulfill obligation
  - Employer’s “…breach of the implied terms…” entitled contractor to damages
Constructive Acceleration – Australia

- Australian courts also recognize “acts of prevention”
  - Employer delays work, refuses EOT & forces acceleration

- Canadian courts
  - Morrison-Knudsen Co. Inc. v B.C. Hydro & Power Authority
  - W.A. Stevenson Construction (Western) Ltd. Metro Canada

- English courts
  - Motherwell Bridge Construction Ltd. v. Micafill Vacuumtechnok

TERMINATION FOR CONVENIENCE
Termination of Contracts – General

- **Definition**
  - Action by employer to end, in whole or in part, work of the contract
- **May also be by contractor**
  - If allowed under terms of contract
  - Example – If work suspended more than 30 days through no fault of contractor by court, government action or national emergency, contractor has the option to terminate involvement in project

Why Need Termination Clauses?

- **Employers may need to “fire” contractor for variety of reasons**
  - Termination for Default
- **Employers may change their mind about major element(s) of contract**
  - Termination for Convenience
- **Employers may need an “out” in event it wrongfully terminates contractor**
  - Termination for Convenience
Owner Terminations – Types

- **Termination for Convenience**
  - Termination of work, in whole or in part, **without** contractor liability or fault
  - Similar to “deductive” variation

- **Default Termination**
  - Permanent cessation of work due to “**material breach**” by contractor in failing to carry out some contractual obligation

Contractor Termination – Causation

- **Based upon contract may be able to terminate involvement in project due to employer –**
  - **Not** provide financial arrangements
  - **Fails** to issue Payment Certificate
  - **Fails** to perform some contract obligations
  - **Prolonged** suspension of work or force majeure delay
  - Employer **bankruptcy** or **insolvency**

- **Contractor may terminate suppliers & subcontractors for default or convenience**
Termination For Convenience – Reasons

- **Reasons**
  - Multiple variations
  - Unbalanced bid breakdown
  - Employer requirements change
  - Shortage of project funding
  - Project no longer needed
- **T for C may be total or partial termination**
- **Owner has great leeway & not typically required to provide reason**

Termination For Convenience – Damages

- Contracts generally provide full payment for:
  - Work done to date
  - Materials delivered & stored on or near site
  - Restocking charges
  - Labor & severance pay
  - Shutdown costs
  - Profit on work completed to termination date
  - But, generally no head office overhead, anticipated profit, or other costs or damages resulting from termination
- **RTFC!**
Termination for Default

- **Action by employer to “fire contractor” due to “material breach of contract”**

  - **Examples** –
    - Failure to mobilize to site & start work
    - Failure to man project to complete work on time
    - Consistent quality of work disputes
    - Substantial failure to follow safety rules
    - Continually performing work in negligent manner
    - Stopping, abandoning work
    - Declaring bankruptcy
Termination for Default

- Employer must provide “cure notice” in writing
  - Detailed list of material breaches
  - Allowing contractor specified time to cure or propose plan to cure breaches
- Has very serious consequences for
  - Employer, contractor, subcontractors, suppliers, financial partners, guarantors & sureties
- Almost automatic invitation to litigation

Default Termination – Analysis

- If contractor receives “cure notice”
  • Any “material breaches” complained of actually employer caused?
    - If so, contractor probably cannot be terminated
  • Owner must have “clean hands”
  • If employer calls on surety
    - Surety entitled to all contractor’s defenses
- If contractor contemplating default of sub/supplier
  • Contractor have “clean hands”? 
  • Can contractor actions withstand legal scrutiny?
Employer Claims

- Late Completion Damages – Damages allowed under contract should contractor complete work late without contractual excuse

  - Actual Damages – Documented damages actually incurred by employer due to project late completion as listed in contract

    - Examples –
      - Continued project management & financing
      - Lost revenue
Employer Claims

• **Liquidated Damages** – Stipulated amount on daily basis agreed to in contract
  ✓ Estimate of damages employer likely to incur if work completed late as estimated by employer at time of tender

➢ **U.S. & Australian law on LDs very similar**

---

Employer Claims

➢ **False / Fraudulent Claims** – Claims based on misrepresentations or falsified records
  • U.S. has False Claims statutes
  • Australia has False Statutory Declarations

➢ **Design Deficiency or Standard of Care Claims** – Claims arising from “negligent” design
  • Failure of designer to meet standard of care for professionals performing design on type of project, in this area & time
Employer Claims

- **Consequential Damages** – Indirect or unforeseeable damages resulting from action or lack of action & not in contemplation of parties at time of contract award
  - Typically, contracts have a Consequential Damages clause prohibiting recovery of such damages
  - U.S. & Australian courts enforce clearly written Consequential Damages clauses
Burden of Proof

- **Claimant (employer or contractor) must prove** --
- **Entitlement or Liability**
  - Event or circumstance occurred on project that gives rise to contractual / legal right to adjustment of time &/or money
    - **Examples**: employer caused delay, differing site condition, variation work, etc.

---

Burden of Proof

- **Causation**
  - Event caused contractor to do something would not have done if event not occurred
    - **Example**: Encounter with unexpected groundwater caused contractor to install & operate a dewatering system on project for 6 months

- **Damages or Quantum**
  - Documented additional time &/or costs + impact damages & appropriate mark up under contract
Burden of Proof

- Burden of proof falls on shoulders of party making claim
  - Responding party **not** have to disprove
- To recover on claim claimant has **obligation** to prove **all 3 elements**
  - If cannot prove all 3, that party will **not** prevail on claim
**Damages - General**

- Damages must be proven with **"reasonable degree of specificity"**
- Delay damages typically require
  - Proof of critical path impact & cost of day of delay
- Impact damages usually require
  - Productivity loss study
- Damages generally fall into –

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**Direct Costs**

- **Costs incurred as direct result of claim**
  - Generally, “hard dollar costs” or “costs of performing extra work”
- **Examples**
  - Labor including fringes & social taxes
  - Material
  - Equipment
  - Subcontractor costs
  - Mobilization & demobilization
  - Storage & laydown area costs
Indirect Costs

- Costs not allocable to specific items of direct work
  - May or may not be time related
- Examples
  - Field office overhead (FOOH)
    - Project management staff & superintendents
    - Site office & equipment
    - Temporary utilities & security
    - Maintenance & clean up
    - Project vehicles
    - Laydown & maintenance area

- Head Office Overhead (HOOH)
  - Corporate management
  - Accounting, HR & other head office staff
  - Engineering
  - Estimating
  - Head office & equipment costs
  - Corporate insurance
  - Central equipment yard
Other Delay Costs

Examples of other contractor delay costs
- Idle equipment
- Idle labour
- Additional or extended storage costs
- Escalation costs of labour, materials & equipment attributable solely to compensable delay
- Labour impact costs
  - Increased labour costs if work would have been completed prior to events but for the employer caused delay

Impact Costs

Costs associated with non-critical path delays
- Productivity loss, impact to unchanged work & cumulative impact

Productivity loss might be claimed using –
- Activity total costs (planned vs. actual costs)
- Measured Mile Analysis (unimpacted productivity vs. impacted productivity)
- Industry standards (actual vs. industry standard)
  - See AACE Recommended Practice 25R-03, Estimating Lost Labor Productivity in Construction Claims
Other Contractor Damages

- **Unless not excluded in Consequential Damages or other contract clauses, other contractor damages may include**
  - Bond & insurance costs
  - Loss of contract bonus
  - Lost profits due to restricted bonding capacity
  - Interest costs
  - Legal fees
  - Claim preparation costs

Employer Delay Costs

- **Examples of employer delay costs**
  - Loss of use
  - Lost rental income
  - Lost profits
  - Delay in proceeds of sale
  - Increased, extended financing costs
  - Extended general conditions &/or other personnel costs
  - Increased storage costs
  - Extended professional fees
Other Employer Damages

➢ **May also include**
  • Repair or replacement cost of defective work
  • Costs to complete project
  • Re-procurement costs in event of Default Termination
  • Extended warranty costs
  • Third party claim costs
General

- Claims arise on **all** project delivery methods
  - No such thing as “bullet proof” contract
  - Only way to avoid all claims – Do not build the project
- Some delivery methods reduce **likelihood** of claims
  - Claims possible whenever contract risk allocation inconsistent with parties abilities to control & manage such risks
- Some currently used project delivery methods include –

Project Delivery Methods

- **Unit Price** –
  - Employer provides detailed list of units to be installed, contractors provide cost/unit
  - Summed costs = Lump Sum Contract price
  - Quantity Variation clauses allow variation costs
- **Design – Tender – Build** –
  - Employer issues fully designed plans & specifications & contractors provide hard dollar price
  - Firm Fixed Price or Lump Sum contract results
  - Contractors entitled to all types of claims
Project Delivery Methods

- **Design – Build** –
  - Design-Build contractor completes design based on employer’s design program & constructs project
  - Most claims other than “defective design” still exist in contract

- **Fast Track Construction** –
  - Construction starts on early portions of work prior to design completion
  - Employer’s risk is coordination of interfaces between design packages

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Project Delivery Methods

- **Multiple Prime Construction** –
  - Employer contracts with independent prime contractors (by trade or project phase) to speed up project delivery & save costs
  - **No Privity of Contract** between primes
  - Whenever one prime impacts another, they pursue recovery from employer
Project Delivery Methods

 Construction Manager at Risk (CM@R)
  • CM@R retained early to provide input to design
  • As design nears completion CM@R provides Guaranteed Maximum Price (GMP) to complete all work
  • Once GMP signed, contractor entitled to all claim types

Project Delivery Methods

 Integrated Project Delivery (IPD) –
  • Three party contract between employer, designer & contractor
  • Establishes risks & responsibilities for each with gain & pain sharing clause & “waiver” of claims between parties
    ✓ Except for claims arising from “gross negligence” or “willful misconduct”
  • Typically works through Limited Liability Corporation
Project Delivery Methods

➢ Public Private Partnerships (P3) –
  • Typically design build approach with developer (contractor) team financing project rather than employer under financing & operating agreement
  • All types of claims available under delivery method

CLAIMS PREPARATION & ANALYSIS
Phase 1 – Entitlement & Causation Analysis

- Identify each issue separately
- Identify & evaluate applicable contract language
- Establish issue files of all related documents
- Analyze each issue separately
- Determine potential for contractual entitlement
- Allocate summary level or order of magnitude costs to each specific issue, if possible, to prioritize further analysis
- Request / locate additional information, if necessary

Phase 2 – Delay Analysis

- Obtain baseline & all program updates in native format
- Compare as planned, updates & as built programs to determine which activities were delayed & whether concurrent delays occurred
- Identify periods of delay, disruption &/or acceleration
- Associate claim issues with identified delay periods
- Perform detailed program analysis of each
- Identify party / parties responsible for each delay
Phase 3 – Damage Analysis

➢ Determine direct costs associated with each claim that has entitlement
➢ Determine potential indirect & impact costs associated with each issue
➢ Determine overhead costs for each issue
➢ Prepare damage calculations for each issue

Phase 4 – Settlement

➢ Complete analysis of each issue before starting negotiations
➢ Meet with other party to negotiate settlement
➢ Use independent mediator or 3rd party neutral to facilitate negotiations, if needed
➢ Once settlement achieved, draft & execute settlement documents with full waiver of further claims concerning each issue settled
  • Involve legal counsel in drafting such language
DISPUTE RESOLUTION METHODOLOGIES

Typical Dispute Resolution Methods

- Negotiation
- Adjudication
- Mediation / Conciliation
  - Use independent neutral
- Arbitration
  - 3 person panel of independent arbitrators
- Litigation
- Other ADR Methods
Dispute Resolution Staircase

- **Litigation**
  - Judge
  - Jury
  - BCA
  - Special Master
  - Arbitration
  - Private Judge

- **Binding Resolution**
  - Mediation
  - DRB
  - Minitrail
  - Conciliation
  - Adjudication

- **Alternative Dispute Resolution**
  - Project Level
  - Executive Level

- **Negotiations**

- **Degree Of Control**

- **$\text{COST}$**

- **TIME**

**CONCLUSION**
Conclusion

- Variations & claims inevitable
- Need not end up in arbitration or litigation
- Good claims management on part of employers & contractors results in claim resolution on project
  - Provided that –
    - Claims well prepared & documented per contract
    - Claims properly analyzed & negotiated
- Employers & contractors need to know how to do both

Questions or Discussion?

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GLOSSARY OF TERMS

The business of construction claims, like many other aspects of modern business, has its own unique set of terms. This glossary sets forth definitions of the more common terms used in construction claims.

**Acceleration**

The employment of unplanned methods of completing work in a shorter duration than planned or required by the contract. Such methods can include overtime work, additional equipment, weekend work, additional crews, or double shift work.

Also refers to conduct by the owner requiring a contractor to complete work earlier than scheduled. Directed acceleration occurs when the owner formally directs early completion, generally through issuance of a change order. Constructive acceleration arises only when all of the following occur:

- Excusable delay occurs
- Proper notice and time extension request are filed
- The owner grants less time than owed
- The contractor is actually or impliedly directed to complete work on time
- Notice of acceleration is given to the owner
- The contractor actually accelerates its activities
- Increased costs are incurred

**Activity**

Discretely identifiable part or unit of a construction project to be used for planning, scheduling, monitoring and controlling the work. Activities consume time and resources. An activity is often confused with an event. Events usually mark the beginning or completion of activities.

**Activity Bar**

A rectangle representing an Activity on the Bar Chart. Its length is scaled according to the time scale. [See: Early Bar and Late Bar]

**Activity Code (Coding)**

Alphanumeric designation system, with code(s) assigned to an activity to group to categorize its properties. Coding is used for detail and summary reporting purposes. [See: Work Breakdown Structure]

**Activity Cost**

The dollar amount expended to complete an activity. Depending upon the cost model and job cost system used, Activity Cost may or may not include indirect costs (jobsite and home office) as well as direct costs.

**Activity Description**

An unique name and word description assigned to an activity which defines the work to be accomplished in general terms.

**Activity Duration**

The best estimate of continuous time (hours, days, weeks, and months) needed to complete the work involved in an activity. This takes into consideration the nature of the work, and the resources needed to complete the task. Baseline Activity Duration development can become very complex when productivity impacts and nonstandard production rates must be utilized to meet the constraints of the project.

**Activity Number / Activity ID**

A unique alphanumeric (most often a pure number) used to identify each activity. [Some project management software programs allow the user the ability to rely solely on Activity Descriptions in lieu of Activity Numbers. Others may not allow alphanumeric Activity Numbers, only pure numbers.]

**Activity On Arrow (AOA)**

An activity network format. Schedule activities are represented by arrows and Nodes are represented by circles. [AOA networks require the use of “dummy” activities to properly model work flow.]

**Activity On Node (AON)**

An activity network format. Schedule activities are represented by boxes or bars and relationships are represented by arrows. [Pure AON networks rely solely on finish-to-start relationships and do not employ the use of Activity Lags to model work flow.]

**Activity Relationship**

Activity relationships determine how activities relate to one another and establish schedule logic. [See: Activity Logic.]

**Activity Splitting**

Dividing an activity into multiple parts to better model how the work is to be performed. e.g. Splitting the activity “Foundation Concrete” into its component parts of “Placing Concrete”, “Curing Time”, and “Stripping Forms”, or separating an activity to insert a Change Order or the like.

**Activity Status**

Information about the performance of an activity that can be used to update schedule progress. Typical status information includes actual start and finish dates, percent complete, and remaining duration. This is information used to update the CPM periodically.

**Activity Type**

Dictates the Calendar used in scheduling software by which a schedule is calculated. Typical Activity Types are: Independent, Task, Hammock, WBS, and Milestone.

**Act of God**

An extraordinary natural event, such as a flood, tornado, earthquake, or tsunami. Also referred to as force majeure.

**Actual Cost of Work Performed (ACWP)**

C/SC² measure of the actual cost of the work performed as of a Data Date. [See: BCWS and BCWP]

**Actual Finish Date**

The date when work on an activity is substantially complete. [Substantial Completion for an activity is when only minor or remedial work remains and successor activities may proceed without hindrance from the predecessor’s remaining work. It is not necessarily the last day work will be performed on that activity.]
Actual Start Date
The date when work on an activity actually started with the intention of completing the activity within the planned duration. [The actual start date is not necessarily the first date work was performed on that activity. Interim starts and stops for an activity may show the need for splitting the activity into component parts.]

Ambiguous Specification
Uncertainty in the meaning of the provisions of a contract requirement, documents or specification. Mere disagreement about the meaning of a provision does not prove an ambiguity exists. There must be genuine uncertainty of meaning based upon a logical and reasonable interpretation of the language used. The entire contract must be taken into consideration.

Analysis
The comparison of actual cost/schedule performance to that planned. This comparison includes the identification of “potential change notices” and their cause. Derives from the monitoring of project expenditures, progress and performance. Requires the application of independent review and creative thought processes to come up with a comprehensive understanding of how, why, and where project accounts are headed. The analysis should result in corrective action to offset/minimize any potential overruns and maximize any potential underruns.

Arrow
A directed line between two nodes in an AOA network used to represent an activity. A solid line is used for actual activities and a dashed line for Dummies.

Arrow Diagramming Method
A method of constructing a logical network of activities using arrows to represent the activities and connecting them head-to-tail. This diagramming method shows the sequence, predecessor, and successor relationships of the activities.

As-Built Schedule
A historical record of the project showing actual start and finish dates for the work performed. An as-built schedule will show logic generally used in the sequence of construction along with actual start and finish dates.

As-Planned Schedule
The plan or baseline schedule the contractor developed to estimate / bid / contract to perform the work. [The as-planned schedule incorporates planned production rates, work calendars, resource availability, logic ties and constraints and activity duration's to meet contract requirements and contractor needs or desires.]

Audit
A formal, independent examination with intent to verify conformance with established requirements through surveillance and inspection. They may be either internal or external.

Backward Pass
Network schedule calculation that determines the latest each activity in the network may start and finish and still maintain the minimum overall duration of the project as calculated by the Forward Pass. It counts backward toward the beginning of the schedule to determine the last possible start and finish dates for each activity that will not delay project completion. [See: Forward Pass]

Bar Chart
Graphic representation of a project that includes the activities which make up the project and placed on a time scale. [Bar charts are time scaled, show activity number, description, duration, start and finish dates, and an overall sequencing of the flow of work. Bar Charts do not generally include the logic ties between activities.]

Baseline Schedule
(1) The original schedule or As-Planned schedule used as a “yardstick” from which to measure progress and aid in making management and control decisions. (2) AGC and others define a Baseline as the Schedule in effect since the last time the schedule was updated. This author disagrees with this interpretation.

Battery Limits
Geographic boundaries, imaginary or real, enclosing a plant or unit being engineered and constructed, and established for the purpose of providing a means of specifically identifying certain portions of work. Generally refers to the process area only, unless specified to the contrary.

Beneficial Occupancy
Use of a facility or project, in whole or in part, by the owner for its intended purpose. This may occur even though some work of the contract remains undone.

Bond, Bid
A bond that is included with the submission of a bid which guarantees that the bidder, if awarded the contract, will execute the contract.

Bond, Payment
A bond that guarantees the payment of subcontractors, suppliers and material men on the project.

Bond, Performance
A bond which guarantees the performance of the work of the contract under the circumstances described in the bond.

Breach of Contract
Failure by either the owner or the contractor, without legal excuse, to perform any work or duty to the other.

Burden of Proof
The requirement to prove the facts in dispute. In a claim, the burden of proof is always on the party making the claim.

Budget
The costs originally associated with the contracted scope of work. [See: Baseline]

Budgeted Cost of Work Performed (BCWP)
C/SC2 measure of the amount of money budgeted to complete the actual work performed as of the data date. Represents the value of work performed, rather than the cost of the actual work performed. Often called the Earned Value.

Budgeted Cost of Work Scheduled (BCWS)
C/SC2 measure of the amount of money budgeted to complete the scheduled work as of the data date.

Calendar
The work periods and holidays defined for the project that determine when the scheduling software may schedule activities. [Scheduling software typically allows for multiple calendars which allows for more accurate modeling of the construction plan. e.g. 5-Day Work Week Calendar vs. 7-Day Work Week. See: Global Calendar]

Causation
The facts and circumstances that produce a result for which a party claims entitlement to compensation.
Change
Additions, deletions or other revisions to the work within the general scope of the contract. A change may be authorized by written directive from the owner to the contractor or informally by a constructive change. In either situation, a change should be formalized through issuance of a change order which makes it part of the contract.

Change, Bilateral
An agreement negotiated between the owner and the contractor for a change to the contract requirements. Agreement includes the scope of the change, the cost and the time impact.

Change, Cardinal
Work beyond that which is required in the contract and is beyond the general scope of the contract. The basic legal test for a cardinal change is whether the type of work is within the contemplation of the parties when they entered into the contract and whether the project as modified is significantly different from the project bid.

Change, Constructive
An act or failure to act by the owner that is not a directed change, but which has the affect of requiring the contractor to perform work beyond that which is required under the terms of the contract.

Change, Unilateral
A change to the contract issued by the owner without the agreement of the contractor as to the cost and/or the time impact.

Change in Sequence
A change in the order of work as initially scheduled or planned.

Claim
Written statement requesting additional time and/or money for acts or omissions during the performance of the contract and for which there is some dispute between the owner and the contractor over entitlement to the time or cost requested.

Commissioning
Activities performed for the purpose of substantiating the capabilities of individual units and systems to function as designed. These activities include such things as performance tests on mechanical equipment, water washing, flushing and drying of equipment and piping, control systems operability checks, checking of safety and fire protection devices, and operation of systems on inert fluids. Commissioning normally follows mechanical completion and ends with initial operation.

Completed Activity
An activity with an actual completion date and remaining duration of zero.

Concurrent Activities
Independent activities which may be or are performed at the same time (fully or partially).

Conflict in Plans and Specifications
Statements in the contract documents, including drawings and specifications, that cannot be reconciled by reasonable interpretation.

Contract Completion Date
The date established in the contract documents for completion of all or specified portions of the work. This date may be expressed as a calendar date or a number of calendar or work days after issuance of the Notice to Proceed. When time extensions are issued by the owner, this revised contract completion date is referred to as the Adjusted Contract Completion Date.

Constraint
Any factor that affects when an activity can be scheduled. Refer to Restraint. A restriction imposed on the start, finish or duration of an activity. Constraints are used to more accurately reflect project requirements. Examples of constraints are: Start-no-earlier-than, Finish-no-later-than, Mandatory Start, and As-late-as-possible.

Construction Progress
Construction progress is monitored and reported as percent complete. Actual work units completed for each prime account are measured against the total required work units as developed from the drawing takeoff of materials. Usually reported against individual accounts by area and total project, and summarized by area and total project.

Construction Progress Report
A report that informs management of the overall field construction progress (physical percent complete), costs, performance and manpower to a specific reporting cut-off date. Also, includes major accomplishments, objectives for the upcoming report period, areas of concern, and other pertinent information necessary for proper management and Control.

Contract Master Schedule
The Management Summary Schedule that shows the overall plan for the total contract.

Contract Dates
The start, intermediate, or final dates specified in the contract that impact the project schedule.

Control
To take timely corrective action. Control occurs only if the monitoring and forecasting activities indicate an undesirable final result is likely to occur and that a different final result is possible.

Control Baseline
The budget and schedule that represent the approved scope of work and work plan for the project. Identifiable plans, defined by data bases approved by FD Project Management and Client Management, to achieve selected project objectives. It becomes the basis for measuring progress and performance, and is the baseline for identifying cost and schedule deviations.

Controlling Relationship
The predecessor activity logic tie to an activity, with multiple predecessors, which “controls” or “drives” that activity and establishes its latest early finish.

Control Level Schedule (Level 3)
Represents detail and individual work tasks, which summarize at the Project Level II activities and deliverables. Clearly shows work by discipline or responsibility, and usually presented in bar chart or tabular form. Maintained by each discipline / contractor in the engineering phase and by superintendents and contractors in the construction phase. Immediate term schedules, also referred to as Weekly Work Schedules, should provide enough detail to manage work at the Foreman level.

Cost, Direct
The cost of labor, materials, supplies, equipment and any other costs related specifically to items of work being performed.
**Cost, Impact**

Added costs indirectly resulting from a change or delay that are a consequence of the initial event. Examples may include loss of efficiency, idle equipment, and extended overhead.

**Cost, Indirect**

Expenses indirectly incurred as a result of direct costs and not directly allocable to a specific work item. Indirect claim costs may include field and home office overhead.

**Cost Loading**

Assigning an estimated cost to an activity. The estimated cost may be only direct costs, or may include jobsite and home office overhead costs. However, the CPM must be developed using only one cost method.

**Cost at Completion**

The amount an activity or group of activities will cost when it has been completed. It is the sum of the cost expended to date and the estimated Cost to Complete.

**Cost to Complete**

The amount that an in-progress activity or group of activities will cost to complete.

**Cost Variance**

The difference between the Actual Cost of Work Performed (ACWP) and the Budgeted Cost of Work Performed (BCWP). A negative Cost Variance indicates that the activity(ies) is running over budget.

**Cost/Schedule Control System Criteria (C/SC2)**

Often called Earned Value analysis used on US Government projects. C/SC2 combines time and cost in the schedule to better measure performance.

**Critical Activity**

An activity on the project’s Critical Path. A delay to a Critical Activity causes a corresponding delay in the final completion of the project.

**Critical Path**

The longest continuous chain of activities which establishes the minimum overall project duration. A slippage or delay in completion of any activity by one time period will extend final completion correspondingly. The Critical Path by definition has no “Float.”

**Critical Path Method (CPM)**

Network scheduling using activity duration's and logic ties between activities to model the contractor’s plan to prosecute the work. [CPM scheduling is the method of choice for managing most construction projects of long duration, complex technical integration, or the need to coordinate fast or early completion of the work.]

**CPM Schedule**

The Critical Path Method (CPM) is a scheduling technique which establishes work activities and the relationship between these activities for the purpose of creating a network of activities used in planning, scheduling and controlling the work. The path of the longest duration of continuous and dependent work activities through the schedule network is identified as the Critical Path and is the minimum amount of time required to build the project as depicted by that schedule.

**Critical Relationship**

A driving relationship between two critical activities, thus defining which activity influences the final completion of the project.

**Data Date**

The Date on which the Schedule has been updated to reflect actual progress (percent complete, remaining duration's, new activities and changed logic, etc. input into schedule) and projects a new completion date. [Scheduling software uses the Data Date to base its network calculations.]

**Deviation (Trend)**

A deviation is any change from the established cost or schedule baseline. The change (positive or negative) may be considered potential or it may already be in the process of actually occurring. The deviation is used to provide a detailed description and detailed estimate (or ROM estimate) of change impacts that are the result of design developments, productivity, omissions, errors, price fluctuation, supplier changes, etc., or anything else that changes the forecast cost and schedules. Deviations are documented by Project Controls and communicated to the Project Manager. A deviation provides the project team with an opportunity to mitigate an adverse impact or to optimize the outcome and is used primarily as a communication tool. The designation “deviation” is synonymous with “trend.”

**Damages, Actual**

The actual increased cost to one party caused by another party’s acts or failure to act.

**Damages, Liquidated**

Amount of money set forth in the contract as being the liability of the contractor for failure to complete the work by the contract completion date or adjusted contract completion date. It is an estimate of the damages the owner is likely to incur in the event of late completion by the contractor. Liquidated damages are typically expressed as a daily rate.

**Date Constraint**

A fixed date imposed on an activity to force it to start or finish by or on a certain date. [A Date Constraint overrides the logic of the schedule and can, if improperly used, caused unintended results.]

**Deceleration**

A direction, either expressed or implied, to slow down the progress of the work.

**Defect, Latent**

A defect in the work which cannot be observed by reasonable inspection.

**Defect, Patent**

A defect in the work which cannot be observed by reasonable inspection.

**Defective Specification, Defective Contract Documents**

Specifications or drawings that contain errors, omissions, ambiguities, conflicts or impossible or impracticable requirements and which prevent the contractor’s performance of portions of the work as contemplated by a reasonable contractor at the time of bidding.

**Delay**

An interference with the progress of a critical path work activity which causes the end date of the project to be later than planned. Delays may be caused by the owner, the contractor, third parties or force majeure events. Delays can be categorized as excusable non-compensable, excusable compensable, non-excusable, and concurrent.

**Delay, Compensable**

Delay that results from owner’s actions or inactions which
entitle the contractor to both a time extension and delay damages.

**Delay, Concurrent**
Two or more delays, within the same timeframe, both of which impact the project’s critical path. If one delay is caused by the owner and the other by the contractor, the contractor is generally entitled to an excusable, non-compensable time extension.

**Delay, Excusable**
A delay caused by an event beyond the control and without the fault or negligence of the contractor (including their suppliers or subcontractors, at any tier) and which was unforeseeable. Excusable delays usually entitle the contractor to a time extension. Excusable delays may be compensable or non-compensable.

**Delay, Non-Excusable**
Delay within the control of the contractor or its subcontractors or suppliers, at any tier. The contractor is not due any time extension or delay damages.

**Differing Site Condition**
Generally refers to either a subsurface or latent physical condition at the site which differs materially from the conditions shown or indicated in the contract documents. It may also include an unknown physical condition at the site, of an unusual nature, differing materially from conditions generally encountered and recognized as inherent in work of the nature provided for in the contract.

**Disruption**
An event which hinders a party from proceeding with construction as planned. Examples include labor inefficiencies as a result of frequent work stoppages, work performed out of sequence, or work performed concurrently with other activities causing a crowded work site.

**Direct Costs**
Costs of completing work which are directly attributable to its performance and are necessary for its completion. [Direct costs normally include labor, material, equipment and direct field supervision, but do not normally include Job Site Overhead or Home Office Overhead.]

**Driving Relationship**
A relationship between two activities in which the start or completion of the predecessor activity determines the early dates for the successor activity with multiple predecessors. See: **Free Float**

**Dummy Activity**
Used only in AOA networks to create logic relationships between activities. [Dummies are “activities” with zero duration, but are not milestones. Dummy Activities are typically drawn as dotted lines.]

**Duration**
The amount of time estimated to complete an activity in the time scale used in the schedule (hours, days, weeks, etc.). [Planned production rates and available resources will define the duration used in a given schedule.] The following 4 types of duration are used:
- **Original Duration**: Duration input by the Planner.
- **Current Duration**: Duration based on latest progress date for in-progress activities; calculated rate of progress provides a new completion estimate.
- **Actual Duration**: Duration based on activity's actual start and actual finish; applies only to completed activities.
- **Remaining Duration**: The expected time required to complete an activity. It is calculated as the difference between the data date and the expected finish date for in-progress activities. (Equal to the original duration for non-progressed activities. Equal to zero for completed activities.)

**Early Bar**
An activity bar shown on the bar chart starting at the earliest date its predecessors’ completion will allow it to begin.

**Early Finish**
The earliest date an activity may finish as calculated by the schedule during the forward pass.

**Early Start**
The earliest date an activity may start as calculated by the schedule during the forward pass.

**Earned Value**
The Budgeted Cost of Work Performed (BCWP). The “value” of the work earned at the date of analysis (data date). Represents the actual value of work performed, rather than the actual cost of the work performed. [Best measure of performance taking into account both time and cost expended]

**Engineered Items**
Items that are purchased to be used for a particular purpose and are engineered to unique specifications, as opposed to commodity materials. This typically includes tagged items and materials that require detailed engineering data sheets.

**Entitlement**
A legal term referring to the contractual rights of the owner or the contractor. To have entitlement it must be shown that the party filing the claim has demonstrated both the facts and the contractual legal right to additional time and/or cost.

**Equitable Adjustment**
A change to the time and/or cost of the contract to compensate the contractor for expenses incurred due to the actions of the owner; or to compensate the owner for reduced work scope. The intended purpose of an equitable adjustment is to leave the damaged party in the same relative time and cost position, after a claim issue or change, as it was prior to the claim issue or change.

**Errors or Omissions**
Generally refers to design deficiencies in the plans and specifications which must be corrected in order for the project to function or be built as intended. Errors are typically things shown incorrectly. Omissions are things not shown. Also referred to as **Defective Specifications**.

**Estimate At Completion (EAC)**
An estimate of the total cost an activity or group of activities will accumulate upon final completion.

**Estimate to Complete (EC)**
An estimate of the remaining costs required to complete an activity or group of activities.

**Exception Report**
A report that lists exceptions to the expected norm as progress and forecast information is compared to the plan.

**Exculpatory Language**
Language in the contract which purports to release the liability of one party for certain actions which may occur during the performance of the work.

**Field Office Overhead**
Expenses incurred by a contractor at the job site in support of a project which cannot be directly associated with a specific work item. Examples include project management staff,
Flow Diagram
A graphic representation that utilizes symbols, labels, and arrows as to depict the details and sequence of operation of a procedure or process system.

Finish-to-Finish Relationship
A relationship in which the successor activity depends upon and can finish only after the predecessor activity finishes. The predecessor must finish first and then the successor can finish.

Finish-to-Start
A relationship in which the successor activity can start only after the predecessor activity finishes. This is the most common relationship used.

Float
The amount of time which an activity may slip in its start and completion before becoming critical. Sometimes called Slack. [See: Total Float and Free Float.]

Home Office Overhead
Expenses incurred by a contractor in support of all projects which cannot be directly allocated to any specific project. Examples include executive salaries, home office rent and utilities, general business insurance, home office accounting and personnel costs.

In-Progress Activity
An activity that has been started but not completed on a given date.

Indirect Costs
Costs not directly attributable to the completion of an activity. [Indirect costs are typically allocated or spread across all activities on a predetermined basis. Indirect costs may be further segregated into Job Site and Home Office overhead costs.]

Idle Equipment Cost
The cost of equipment which remains on site ready for use, but on a standby basis. Ownership costs typically continue to be incurred even when equipment is idle.

Implied Duties and Obligations
Principles of general contract law imposed upon both parties even if not stated in the contract. Examples include the duties of non-interference and cooperation that exist between the parties to the contract.

Implied Warranty
The legal theory that when an owner requires a contractor to build the project in accordance with plans and specifications, the owner impliedly warrants that the plans and specifications furnished are adequate to accomplish the work.

Impossibility
A contract requirement which is physically impossible to perform. To be impossible, it must be shown that ~ contractor could perform the work required, not that just one contractor cannot perform it.

Impracticability
Inability to perform work called for under a contract due to unforeseeable extreme and unreasonable costs. This is considered to be an economic impossibility even though the work requirement may be physically possible to perform.

Inefficiency
A level of production which is less than that accomplished under normal working conditions.

Hammock Activity
An activity which spans a group of activities and is used for summary reporting purposes. The hammock activity does not affect schedule dates of the activities it spans.

Histograms
Graphic representations of resource availability levels and resource utilization levels measured against a selected magnitude scale and plotted in time relationship.

Holiday
Non-work days / periods that do not occur on a weekly basis. [Holidays typically occur on a yearly basis. In the US holidays may include New Years, Memorial Day, Independence Day, Labor Day, Thanksgiving and Christmas.]

Home Office Overhead
Expenses incurred by a contractor in support of all projects which cannot be directly allocated to any specific project. Examples include executive salaries, home office rent and utilities, general business insurance, home office accounting and personnel costs.

I Node
In an AOA schedule, the node at the beginning of the activity arrow.

I Node
In an AOA schedule, the node at the beginning of the activity arrow.

Idle Equipment Cost
The cost of equipment which remains on site ready for use, but on a standby basis. Ownership costs typically continue to be incurred even when equipment is idle.

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Inefficiency
A level of production which is less than that accomplished under normal working conditions.
**Interference**
Conduct that unreasonably interrupts normal operations and hinders performance of the work. See Disruption.

**J Node**
In an AOA schedule, the node at the end of the activity arrow.

**Lag**
Time that an activity follows, or is delayed from the start or finish of its predecessor(s). Sometimes called an Offset.

**Late Finish**
The latest date an activity may finish as calculated by during the backward pass.

**Late Start**
The latest date an activity may start so the project may be completed on time as calculated during the backward pass.

**Latent Condition**
A concealed or hidden condition which cannot be determined by a reasonable inspection.

**Loss of Productivity**
See Inefficiency.

**Logic Diagram**
Graphic diagram of a network schedule showing the relationships between a particular activity and its predecessors and successors.

**Logic Constraint**
A restraint inserted in an AOA network which defines dependent relationships between two activities.

**Look-Ahead Schedule**
A short period (two or three weeks) schedule, typically presented in bar chart format showing what needs to be accomplished to keep the project on schedule. [Look-Ahead schedules are often discussed at weekly project meetings to coordinate and control the following week’s work.]

**Loop / Logic Loop**
A error in the network logic resulting from successor activities, also being a predecessor to the activity in question. Also known as Circular Logic. [Logic loops can be very frustrating to eliminate in complex network schedules.]

**Lead**
Time that an activity precedes the start of its successor(s). Lead is the opposite of Lag.

**Leveling / Resource Leveling / Resource Optimization**
Utilizing resource availability profiles, scheduling software can adjust activity duration's and reschedule the project to more accurately model expected performance.

**Level of Effort (LOE)**
Support type effort (e.g., vendor liaison) that does not readily lend itself to measurement of discreet accomplishment. It is generally characterized by a uniform rate of activity over a specific period of time.

**Level Of Detail**
All projects need to determine the level of detail requirements for estimates, accounting reports, cost reports, scheduling reports, and types of schedules. Determining the level of detail should consider requirements to execute the project and meet historical data requirements.

**Level Of Effort (LOE)**
Support type effort (e.g., vendor liaison) that does not readily lend itself to measurement of discreet accomplishment. It is generally characterized by a uniform rate of activity over a specific period of time.

**Levels of Schedules**
The 3 main levels of scheduling are the following:
Management Summary, Project Level, and Control Level. The level of schedule is differentiated by the degree of detail in the schedules.

**Linear Scheduling Method (LSM)**
Scheduling method that may be used on horizontal projects (pipelines, highways, etc.) Highly repetitive tasks make up the majority of the work. [LSM schedules use “velocity” diagrams representing each activity. LSM scheduling is not widely used]

**Logic**
The ties between an activity’s predecessor and successor activities which determines the sequence to be followed. [Activity Logic is determined by the need to meet competing constraints defined by the contract requirements, physical capabilities of the trades performing the work, safety concerns, resource allocations, and preferential relationships between activities.]

**Material Difference**
A change of condition which will have a significant impact on the performance of the work in terms of means and methods, time and/or cost.

**Misrepresentation**
Factual information which is false or misleading, even if unintentional, and would have made a difference in the performance of the work if known to both parties at the time of contract formation. May also refer to information known or available to one party but not identified to the other party during bidding (either intentionally or unintentionally).

**Mitigation of Damages**
The responsibility of both parties to a contract to minimize damages (time and cost) to the other party.

**Management Summary Schedule (Level 1)**
The level of schedule containing the least amount of detail, typically including major functions, milestone objectives, master schedules, and bar chart summaries of project status. Used by management and the client to monitor all aspects of the project. It is a roll up of the Project Level Schedule (Level 2).

**Manpower Analysis**
A comparison of planned versus actual labor provided to the project to evaluate progress of the work.

**Mechanical Completion**
Unit is essentially complete for startup operation and test run. All major work completed. Minor work not interfering with operation may not be completed, such as punch list and minor touchup work. Acceptance letter will have been submitted to the Client. Precise definition may vary and is usually a contractual provision. Client custody may commence. It is important that this definition be clearly defined in the contract.

**Milestone**
A zero duration “activity” or “event” which is used to denote a particular point in time for reference or measurement. [Milestones are not true activities in that they do not consume time or resources.] Often used for Management Summary reporting.
Multi-Project Scheduling
A technique used to consolidate multiple project’s CPM schedules into a Master Schedule. This technique is used to monitor and control the overall Program.

Must Finish By Date
The date used by scheduling software to calculate the final completion status of the project. Without the imposition of a Must Finish By Date, the end of the project would float out to its natural completion.

Negative Float
The amount of time by which the early finish of an activity is later than its late finish. It is how far behind an activity is and is considered a Critical Activity.

Network Diagram
Same as a Logic Diagram.

Network Scheduling
Method of Planning and Scheduling a project where activities are arranged based on predecessor and successor relationships. [Network calculations determine when activities may be performed, which activities have float, and the critical path activities.]

Network
The series of activities required to complete a project. [See: Critical Path Method (CPM)]

Node
In an AOA schedule, the event marking the start (I node) or finish (J node) of an activity. [Nodes are typically represented graphically as a circle.]

Notice to Proceed (NTP)
A directive given by the owner to the contractor to proceed with the Project or a given phase of work.

Original Duration
The planned estimated of total time necessary to complete an activity.

Out-Of-Sequence Progress
Work that takes place on an activity prior to its successor(s) activity being complete or conducted out of sequence as defined by the schedule’s baseline logic. [Scheduling software may include a “switch” to turn on or off how the calculations deal with out-of-sequence progress.]

Owned Equipment Costs
Expenses incurred in owning and maintaining equipment, such as depreciation, replacement cost, repairs, maintenance, taxes, insurance, and storage.

Path
A continuous chain of activities within the network.

Percent Complete
An estimate of the percentage complete for an activity as of a particular data date. [Percent Complete may be based on time expended, cost or resources employed, or measurement of work in place. See: Quantity Survey and Remeasurement]

PERT (Planning Evaluation And Review Technique)
Along with CPM, PERT is a technique for planning and evaluating progress of complex programs. Attempts to determine the time required to complete each element in terms of pessimistic, optimistic, and best-guess estimates.

Physical Percentage Complete
A portion of the actual accomplishment of the work being reviewed as of a particular date. Physical completion of any activity represents the most accurate appraisal of the immediate supervisor tempered with judgment, experience, and/or his department’s historical data developed for that activity. Physical completion is in no way linked to the work hours budgeted or expended.

Plan
The formalized, written method of accomplishing a project task.

Planning
The identification of the project objectives and the ordered activity necessary to complete the project (the thinking part) and not to be confused with scheduling; the process by which the duration of the project task is applied to the plan.

Planning Session
A meeting of the principal members of the project team for the purpose of establishing a consistent scope basis for control by defining manageable segments that meet the specific needs of the project.

Precedence Diagramming Method (PDM)
A superset of the AON method which allows additional precedent relationships along with lead and lag times. [See Start-to-Start, Finish-to-Finish and Start-to-Finish relationships. Zachry Co. pioneered the use of PDM schedules.]

Predecessor Activity
An activity which must necessarily be completed before its successor activity may start.

Pricing, Forward
Estimation and agreement of the cost of work prior to any work being performed. Also referred to as Prospective Pricing.

Pricing, Retrospective
Pricing of work after some or all of the work has been performed. The actual costs of the work performed may be used to arrive at the price. Also referred to as Force Account or Time and Materials (T&M) Pricing.

Production Rate
The amount of work which may be accomplished in a given time unit.

Production Schedule
Short-interval schedule used to plan and coordinate a group of activities.

Program
A grouping of related projects usually managed by a Master Schedule.

Progress
Development to a more advanced stage. Progress relates to a progression of development and therefore shows relationships between current conditions and past conditions. Refer to Status.

Progress Override
One of two types of scheduling software logic used to handle activities that occur out of sequence. When specified, it treats an activity with out-of-sequence progress as though it has no predecessor constraints; its remaining duration is scheduled to start immediately, rather than wait for the activities predecessors to complete. [See: Retained Logic]

Project
A unique undertaking aimed at achieving specific predefined goals and objectives.
Project Controls
The official department title. Primary functions provided by the department include all estimating, scheduling, project finance, field accounting, payroll, and cost control activities in support of Project Management.

Project Duration
The overall duration a project is scheduled to be completed within. Contractual requirements may impose a given project duration for successful completion, from which the schedule is developed to achieve.

Project Level Schedule (Level 2)
An activity- and deliverable-centered schedule containing a middle amount of detail in time-scaled network diagrams or bar charts. It integrates the project’s engineering, procurement, and construction activities by network logic, identifies critical path and key project dates, and provides measurement of accomplishments against established objectives. The CPM (Critical Path Method) scheduling technique is used to develop the Project Level Schedule. The status of the detail activities summarizes to the Management Summary Level 1 Schedule.

Project Start Date
The date a project is scheduled to start. Scheduling software uses the Project Start Date as the starting date for all network calculations until a Data Date is used for calculating updated progress.

Quantity Survey
A formalized method of periodically (typically monthly) detailing the actual progress accomplished on individual activities and the units of work performed or put in place. Often used on Unit Price contracts and on International civil works projects. [See Remeasurement]

Remaining Duration
The estimated remaining amount of time necessary to complete an in-progress activity.

Remeasurement
A type of contract which provides the use of Quantity Surveys to measure progress.

Rented Equipment Costs
The amount which the owner of the equipment (the lessor) charges to a renter (the lessee) for use of the equipment. Such charges may be on an hourly, daily, weekly or monthly basis and are generally supported by rental invoices.

Resource Calendar
Used by scheduling software to define the resources and their availability on a project. [See Resource Loading]

Resource
Manpower, materials, equipment, and money available or required to perform.

Resource Loading / Resource Allocation
The process of allocating or defining, through the use of Resource Calendars, the resources to be used on given activities.

Resource Constraints
The limitations on available resources. [See Resource Calendar]

Responsibility Code
System of applying an alphanumeric tag to an activity for grouping, sorting and summarization purposes. The Responsibility Code generally identifies the entity responsible for performing the coded activities. e.g. Assigning the code “MECH” to the mechanical subcontractor’s work activities.

Retained Logic
One of two types of logic used to handle activities which occur out of sequence. When used, scheduling software schedules the remaining duration of an out-of-sequence activity according to current network logic - after its predecessors. [See: Progress Override]

Rest Day
A day where no work is schedule on an activity or the project. [See Calendar]

Schedule
A description of when each activity in a project can be accomplished and must be finished so as to be completed timely. The simplest of schedules depict in Bar Chart format the start and finish of activities of a given duration. More complex schedules, general in CPM format, include schedule logic and show the critical path and floats associated with each activity.

Schedule Percent Complete
The proportion of an activity or all the project’s activities that has been completed.

Schedule Compression
A method of schedule analysis used to shorten the Critical Path of the schedule. This may be accomplished by resequencing work, employing greater resources to accomplish more work in a given time, or otherwise reducing the duration of critical path activities. The need for schedule compression may come about because of the owner’s desire to complete early, make up for delays, or to accommodate added work.

Schedule Decompression
The opposite of Schedule Compression and results in lengthening the critical path. [The need to reduce costs, work within limited resource constraints, or to eliminate the use of overtime are some of the reasons for Schedule Decompression.

Schedule Graphics
Presentation charts and images used to communicate schedule progress and highlight areas of concern. Usually supplements the Schedule Report. Schedule Graphics can include Bar Charts, Time Scaled Logic Diagrams, Fragments, etc.]

Schedule Report
A periodic report outlining progress, highlighting significant progress of activities on the critical path and areas of concern which may require corrective action. [The Schedule Report typically includes a narrative, tabular listings by various sorts, and time scaled CPM diagrams.]

Schedule Update
The process of updating progress as of a Data Date and reporting that progress.

Schedule Variance
The amount of time by which the Earned Value (BCWP) differs from the Baseline Schedule.

Short-Interval Scheduling
The process of updating CPM schedules weekly or even daily, and generally using activity duration's in hours and days. [Short-Interval Scheduling is employed in Plant Shutdowns / Turnarounds or for very time critical / short duration sub-projects.]
Stop Work Order
See Suspension of Work, Directed

Substantial Completion
Work which is ready for occupancy and use for its intended purpose.

Superior Knowledge
See Misrepresentations

Surety
A bonding company licensed to conduct business in the state where the project is located and authorized by appropriate government agencies to issue bonds. Sureties issue bonds which, under certain circumstances, provide a guarantee to the owner that the project will be completed by the contractor (Performance Bond) and that all subcontractors and suppliers will be paid by the contractor (Payment Bond).

Suspension of Work, Constructive
An act or failure to act by the owner which is ~ a directed suspension of work but which has the effect of delaying or interrupting all or a portion of the work.

Suspension of Work, Directed
An order or directive from the owner to the contractor to stop all or a portion of the work.

Slack
Same as Float.

Start-to-Finish
A relationship in which the successor activity depends upon and can finish only after the predecessor activity starts. The predecessor must start first and then the successor can finish.

Start-to-Start
A relationship between activities in which the start of a successor activity depends on the start of its predecessor. The predecessor must start prior to the successor starting.

Substantial Completion
For an activity, when the work is generally completion with the exception of minor remedial work, thus allowing any successor activities to start unimpeded. For a project this is the point where the work is complete and the owner can start using the project for its intended purpose. The only remaining work would be categorized as punch list work.

Successor Activity
An activity which logically follows the accomplishment of part or all of a given activity.

Time Unit
Generally expressed in hours, days or weeks, the expression of the duration of an activity.

Time-Constrained Scheduling
The network schedule calculations are constrained by the time allowed to complete the project as opposed to the resources available to do the work.

Termination
Action by the owner, under the terms of the contract to end in whole or in part, the work by the contractor on the project. Termination may be either for the convenience of the owner or for default by the contractor.

Third Party Claim
Claims against either the owner or the contractor by persons not party to the contract; for example, an adjacent property owner claiming damage to their property.

Time Extension
An increase in the contract’s time of performance, generally through issuance of a change order.

Time-Scaled Logic
A Bar Chart schedule presentation that includes the logic ties between activities.

Total Float
The amount of time an activity can be delayed before it affect the project completion date or an intermediate milestone. [See Free Float]

Unusually Severe Weather
Adverse weather which is unusual for the time of year and the area. If the contract does not define this term then, generally, the actual weather is measured against the ten year average weather for the time of year and the location of the project. Regardless of how severe the weather, if it is not unusual for the area and time of year, the contractor is typically not entitled to relief.

Update Date
See: Data Date.

Variance
The difference between what was originally expected and what actually happened. [See Schedule Variance, Cost Variance and Completion Variance]

Velocity Diagram
A graphical presentation of production schedules which shows the relationship of the output of work crews / equipment spreads as a function of time.

Work Breakdown Structure (WBS)
Framework for organizing and ordering the activities that make up a project. Systematic approach to reflect a top-down structure with each lower level providing more detail and smaller elements of the overall work.

Work Day
Any days that are not rest days or holidays when work can be scheduled.

Work Week
The calendar that describes the number of Work Days in a typical week.

Zero Float
An activity has zero float when the Early and Late Start / Finish Dates equal each other. Activities with Zero Float are considered to be on the Critical Path(s) of the Project even when there are activities with Negative Float.
AACE International Recommended Practice No. 52R-06

TIME IMPACT ANALYSIS – AS APPLIED IN CONSTRUCTION
TCM Framework: 6.4 – Forensic Performance Assessment, 7.2 – Schedule Planning and Development, 10.2 – Forecasting, 10.3 – Change Management

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PURPOSE

This Recommended Practice for Time Impact Analysis (TIA) is intended to provide a guideline, not to establish a standard. This recommended practice of AACE International on TIA provides guidelines for the project scheduler to assess and quantify the effects of an unplanned event or events on current project completion. While TIAs are usually performed by a project scheduler and can be applied on a variety of project types, the practice is generally used as part of the Total Cost Management (TCM) change management and forecasting processes on construction projects.

OVERVIEW

This recommended practice focuses on the basic elements necessary to perform a Time Impact Analysis (TIA). Necessary considerations and optional analysis practices are described. The TIA is a ‘forward-looking,’ prospective schedule analysis technique that adds a modeled delay to an accepted contract schedule to determine the possible impact of that delay to project completion. This practice is not recommended for a retrospective (hindsight or forensic) view taken after a significant passage of time since the delay event.

This TIA practice concerns itself with time aspects, not cost aspects of projects. The time impact must be quantified prior to determining any cost implications. No practical advantage is obtained by including cost factors into a time impact analysis. 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; eliminating the cost-driven considerations from both ‘creator’ and ‘approver’ of the TIA.

A TIA may be performed to evaluate the potential or most likely results of an unplanned event. This event may be either schedule acceleration or a delay. For simplicity and clarity, we will refer to this event as a delay (i.e., acceleration can be considered as a negative delay).

RECOMMENDED PRACTICE

Time Impact Analysis

Overview

Unplanned delays on a construction project are often regrettable but unavoidable. If the party responsible for executing the contract (Contractor) has been delayed by the effects of a change in the work or an event that was beyond his or her ability to reasonably foresee and plan for in the bidding process, then the entity responsible for overseeing the contract (Owner) may be obligated to adjust the contract, depending upon the terms of the contract.

TIA is a simplified analytical procedure typically specified on construction projects to facilitate the award of excusable days to project completion, due to delays that were not the responsibility of the Contractor. The TIA process may also be used by the Contractor as an internal method to evaluate alternatives to regain or improve project completion for delays caused by the Contractor.

Construction law in most localities require the injured party (in this case the Contractor) to petition for a contract time extension, if they have been delayed by the actions or inactions of parties not under their control. To this goal, many contracts specify that a TIA be prepared and submitted to objectively substantiate the Contractor’s request for a time extension. Once the duration of time has been agreed upon then the added time-related costs of such a delay can be determined in terms of the contract.
The TIA procedure should be reduced to the most basic level possible and still reflect a reasonable assessment of the result of a delay. It is recommended that the time adjustment to the contract be calculated quickly, using an agreed upon standard method, with the results appropriate to the actual delay to a reasonable degree of certainty. The Owner should approve or reject this TIA strictly in accordance with contract terms and the same standard as was used by the Contractor. Time Impact Analysis is not an attempt to simulate reality, only to approximate it. It is a recognized analytical technique intended to facilitate a reasonable estimation of the time impact to the project caused by a single delay event or series of events.

The TIA procedure is performed while a project is on-going, and thus has a ‘forward-looking’ or a “prospective analysis” perspective in near-real time. Retrospective (hindsight) forensic research and analysis is not desired or required as a TIA is a forecast designed to facilitate a timely contract adjustment prior to the actual work being completely performed.

The longer the period between the delay and the approval of the TIA, the less useful and valid the TIA becomes. Because ‘time’ is the issue being negotiated, the value obtained from a timely resolution of this contractual adjustment is greatly diminished by delay in preparation and/or approval of the TIA. Delay in approval of a TIA may result in a supplemental claim by the Contractor of constructive acceleration. At some point, delay in preparation and/or approval of a TIA so diminishes the value of the analysis that the inherent inaccuracies of a TIA invalidates the use of this simple procedure and calls for a more thorough retrospective, forensic analysis.

The TIA is typically associated with the modeling of the effects of a single change or delay event. It requires a Critical Path Method (CPM) schedule that is able to show the pure CPM calculation differences between a schedule that does not include a delay and one that does include an activity modeling the delay event. The difference for project completion, between the non-impacted schedule and that of the schedule with the impact, is considered to be the impact of the delay for time duration considerations.

TIA assumes that the most recently accepted schedule update, just prior to the actual delay, correctly displays the project status and logical sequence of work involved on the project at the time of the delay. It also assumes that the Contractor’s and Owner’s responses to that delay are independent of the rest of the project and that the actual delay will not result in a change in the project work plan. In effect, a TIA assumes that the CPM schedule, in-effect at the time of the delay, is ‘frozen’ and will not change (other than the change brought about by the delay.) The above assumptions provide a means of quickly analyzing the impact of the delay, but they can also introduce subtle (and sometimes not so subtle) inaccuracies under certain conditions.

Should the assumption of an Update Schedule, with correct and timely accepted status and logic, be incorrect an additional preliminary step should be taken. Before a TIA may be accomplished, an accepted CPM schedule, with a status date immediately just prior to the delaying event, must be developed that has no reference to the delay in question. Maintaining a set of timely, accepted, schedule updates is very important to the TIA success.

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 respond to the results of the analysis and 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 in an analytical tool, such as a Window Analysis. Other delay analysis techniques such as Windows Analysis and As-Built Analysis are generally more accurate and reliable, but these are usually far more expensive to prepare, more time-consuming, and require more expertise, research, and preparation time to complete.

**COMPARISON GUIDELINE:** As a general guideline, TIA is more or less acceptable and useable for the determination of delay impacts under the following circumstances:
More Useable:

- **Frozen work plan** If the Contractor has not been given remediation direction and is not able to redeploy his work force in order to remain in readiness for resumption of work, then the work plan is said to be ‘frozen’ and the assumptions inherent in a TIA remain valid.

- **Forward looking** Delays expected to occur or occurring at the present time are better subjects for a TIA then those that have already finished. Using actual durations in place of estimates then suggests the need for a review of operational efficiency of the actual work and the removal of any of the time also spent on contract work during the delay period. In addition, the tendency for parties to wait and observe the actual durations is in conflict with the primary purpose of timely resolution in TIAs.

- **Short duration of delay** In general, TIAs are intended to model delays of less than one reporting period. If longer periods are considered, then an additional step (detailed below) must be considered. This optional step is needed to address the legal requirement and natural tendency of the Contractor to mitigate any delays where the mitigation does not involve additional costs. Mitigation effects become more pronounced as time progresses after a delay has occurred.

Less Useable:

- **The more your schedule update does not reflect actual conditions at the time of the delay** The longer the time period between the date that the schedule update reflected the status of the project and the date of the start of the delay event, the more conditions will have changed between the planned forecast schedule and the actual work schedule before the time of the delay. The schedule update used to model the delay must reasonably reflect the work plan in effect at the time of the delay.

- **The less linear (or serial in nature) of the work plan** Work plans based upon resource considerations are more easily adjusted without detriment to the project completion or planned expenses than those based upon physical constraints. Resources may possibly be redeployed to areas not affected by the delay. Work plans involving physical process steps dependent upon earlier work being completed (serial in nature) will likely be harder to mitigate.

- **If more mitigation was accomplished during the delay** This can have the opposite effect of that of a ‘frozen’ work plan. The more work that was performed ‘out-of-sequence,’ the more construction restrictions waived, the more effort that is performed by either the Owner or Contractor on behalf of reducing the effects of a delay upon project completion, the less effective a TIA will be in modeling the effects of a delay.

**Specification**
The process diagram in Figure 1 depicts a recommended TIA procedure.
Figure 1 — Recommended TIA Flow Chart

1. Submit a schedule fragment modeling the delay.
   
   Accepted?
   
   Yes
   
   2. Select the appropriate update schedule.
      
      3a. Insert fragment into schedule. Reduce delay durations to zero, and do Network calculations.
      
      Do all calculated dates match the original schedule?
      
      Yes
      
      Is the delay period long or has mitigation occurred?
      
      No
      
      3b. Perform either procedure.
      
      Redesign logic to reflect an optimum response.
      
      Reduce durations to that at the end of the delay period.
      
      4. Insert approved durations into delay activities and recalculate the CPM.
      
      5. Identify the activity that will be used to measure the time impact.
      
      6. Determine the total time impact to the project.
      
      7. Determine the actual dates of delay.
      
      8. Eliminate delay dates already awarded.
A TIA is accomplished by following the following steps,

**STEP 1:** Model the Impact with a Schedule Fragnet. The schedule fragnet should consist of a subset of the activities in the project schedule that will be involved directly with the delay. For ease of comprehension and review, the delay should be described as simply as possible. Use the fewest number of activities and relationships added in order to substantially reflect the impact of the delay to the schedule. Shown detail should be consistent with the nature and complexity of the change or delay being modeled. Added activities should be numbered in a logical manner to make it easy to distinguish them as new activities associated with the delay.

Care should be used to correctly define the change or impacting activity and describing the logical insertion into the fragnet. Existing activities and logic should be left intact whenever possible except to incorporate the fragnet. Added relationships may cause some of the existing relationships to become redundant to the CPM calculation, but relationships should only be deleted when the retention of that relationship would negate the actual work restraints on the project. Redundant relationships caused by the additional inserted logic should be left in the schedule wherever possible and should not affect the overall result.

It is acceptable to add a delay as a successor to an activity when in fact, that delay occurred during the activity and delayed its completion. It is also acceptable to split the existing delayed activity into two activities, with one representing the portion of the planned work to be performed before the delay, and the other portion of the planned work after the delay, as long as the combined durations of the split activities equals the original duration of that activity.

**Cost Considerations**

It is intended that the TIA separate time from cost considerations. Costs should be derived after time has been established, not traded back and forth as a negotiating position. To this end, the impacted fragnet should first be isolated from the schedule to be analyzed. Owners who claim that they cannot approve a fragnet until they know the extent of the impact on project completion are simply trying to negotiate costs at the same point as they negotiate time. They are making time a function of costs. The time impact is a function of the impacting activity and not the other way around. Care should be used to correctly define the change or impacting activity and describing the logical insertion into the fragnet. If this is done correctly, then the ultimate results of the TIA will also be correct.

To this end, the Owner should review, negotiate (if necessary,) and agree on the fragnet before proceeding with the further steps. It is acceptable to combine all of the following steps into one, however, the Owner still needs to approve the step considerations in order to approve the TIA.

**STEP 2:** Select the appropriate accepted schedule update to impact. The appropriate schedule should be the last Owner-accepted schedule statused and updated prior to the time of the change or delay. The baseline schedule should be used if the delay began prior to the first schedule update.

If the time interval between the start of the delay and the last accepted schedule update is too great (or if significant deviation to the schedule was experienced between the last status date and the start of the delay), the Contractor may elect to first provide a new schedule status and update with a status date immediately prior to the start of the delay. Before this new update schedule is to be used, it should first be submitted to the Owner for review and acceptance, just like any other schedule update for that project.

The schedule to be impacted is called, “the original schedule update.” The status date should not be altered from that used by the original schedule update and the impacted schedule.

Constraints not required by contract and not included in the Accepted Baseline Schedule should not be included in the analysis. Other constraints may be considered on a case-by-case basis, but this should be...
fully documented. The object is to remove constraints that do not affect the contract assumptions made when the contract was awarded.

Non-contractual constraints should be removed and contractual constraints reduced to the least restrictive, before proceeding to the next step. The resultant original schedule update should not be used for any purpose other than the TIA in question. Any constraint that is to be retained for the TIA should be the least restrictive constraint that still describes the contract requirement.

Following is a list of constraints from least restrictive to most restrictive:

- Start No Later Than;
- Finish No Later Than;
- Start No Earlier Than;
- Finish No Earlier Than;
- Start On;
- Must Finish; and
- Must Start.

An automated TIA is only valid if the CPM software, being used to model the effects of a delay event, properly shows the effects of the CPM calculations. This includes the consideration of a status date, out-of-sequence progress, and actual activity status. The schedule should not allow any unstarted activity to be scheduled prior to the status date. Also, it should not allow for a prediction of early completion for an unfinished activity prior to the status date. Work actually performed on activities that are not logically able to begin should be considered. The schedule should not contain activities with actual starts or actual finishes later than the status date.

**STEP 3a:** Insert the fragnet into a copy of the current schedule update prepared as described above. Using the accepted fragnet as a template, add the impact activities and logic. Make the accepted activity adjustments to the existing activities as necessary to mirror the fragnet. Set the duration of the delay activities to zero and recalculate the CPM. At this point in the analysis, all computed and actual dates in the original schedule update should match that from the original schedule update. If all dates do not match, then correct the fragnet insertion until they do match.

**OPTIONAL STEP 3b:** If the delay time period involved is long, or if substantial mitigation of the delay has occurred, then an optional step may be needed to consider the effects of mitigation. This step is necessary if mitigation efforts by either the Owner or Contractor have modified the actual impact of a delay on project completion. Skipping this step in this circumstance may result in a calculated time impact that does not closely relate to the actual impact. There must be a correlation between calculated and actual for a proposed TIA to be acceptable.

Construction law requires that the Contractor mitigate the effects of any delay to the extent practicable. If Step 3b is not implemented, a statement should be provided with the TIA to explain why this step was unnecessary. The reasons for not implementing Optional Step 3b may include the following: a frozen work plan, forward-looking impact analysis, and shortness of duration of the delay.

In lieu of actually redesigning the logic, that was in effect when the delay occurred, to that which was actually used after the delay occurred, the Contractor may elect to revise the remaining duration status of every activity in the schedule to the remaining duration status evidenced at the time of the actual end of the delay. This revision of the status to the impacted schedule will reflect the resultant effects of mitigation of the project. Activities performed out-of-sequence will still exist as successors to the impacted activity, but their remaining durations will be reduced to reflect the work performed during the delay period.

Whatever changes made to the schedule to satisfy the Step 3b requirements, should be fully documented and included as part of the TIA submittal. These changes are subject to review, negotiation, and acceptance by the Owner.

**STEP 4:** Insert the durations used in the fragnet into the added delay activities and recompute the CPM.
STEP 5: Identify the activity indicating project completion and note any change in the project completion date. This analysis is primarily interested in the estimated early completion of the last project or contract milestone prior to demobilization (usually substantial completion.) This identification is important for any subsequent entitlement for time related damage. The delay or acceleration effect to all contractual milestones not completed should be noted and documented.

STEP 6: Determine the correct time impact for the project delay. If the contract specifies work days, then this unit of measurement should be made in work days. If the contract specifies calendar days or specifies an absolute date for completion, then the unit of measure should be made in calendar days.

STEP 7: Determine the actual dates of the delay. Using the original schedule update, determine when the successor activity to the delay impact actually became a project critical activity. On schedules without negative float, the activity will be predicted to become project critical on the computed late start date. The first date of delay due to this impact will be the next day after the activity late start date. For original update schedules that do show negative float, the start or delay date will simply be the first day of the delay event. Every day after this start of delay will be labeled a delay day (counting work days or calendar days as appropriate) until the number of delay days is exhausted.

The above procedure assumes (either by contract or standard default) that project float belongs to the party who uses it first. It also assumes that the project does not meet all legal requirements for a declared early project completion. If either of these assumptions is incorrect, then the appropriate adjustment should be made in counting the delay days.

STEP 8: Eliminate delay dates from the TIA request that have previously been awarded. Every date determined to be a delay date will be excusable to contractual milestone completion, providing that this date has not already been awarded as a delay date due to a prior TIA or other excusable event, such as an adverse weather date. Should the day already be designated as an excusable delay date, then this day will be considered concurrent in terms of a previous delay. In no event will a single date be granted an additional excusable day if it has previously been granted one for any other reason. In other words, no single date may be assigned more than one day of excusable delay.

Concurrent Delay Analysis
Concurrent Delays are delays to activities independent of the delay that you have considered, but occurring at the same time as the delay in your TIA. Many contracts require a TIA to include an analysis of concurrent delays (especially attributable to the party not responsible for the delay being analyzed in the TIA.) This is because most contracts will consider concurrent delay days as 'non-reimbursable' or excusable, but non-compensable. As this Recommended Practice does not concern itself with costs, this cost analysis issue may be performed separately after the TIA.

Step 7 above will ensure that the in-progress TIA analysis will eliminate the counting of time extensions of concurrent days already granted in earlier TIA analyses. The only possible remaining concurrent delay issues, to be considered, result from actual independent delays caused by the Contractor during the delay time in question. While important as a cost impact issue, this has no bearing on a TIA. Legally, excusable delay should be granted regardless of any contributing Contractor concurrent delay on that same date, provided that the terms of the contract do not specifically preclude this result.

The issue of compensability of delay damages is dependent upon the lack of (or contributing factor in) Contractor concurrent delays on any given date. They should be included in change order considerations, but not a TIA. A TIA should be solely concerned in time impacts, which have already been calculated using the steps above.

Finally, it is noted that there is no single, legal definition of the term, "concurrent delay." Some consider this to be any day that the Contractor did not work during the delay period. Others consider it to be any identifiable delay to any activity with negative float. Still others consider this to be any delay to an activity that had the same or lower total float as the TIA delay. Until there is legal consensus, this issue will not be included in a Recommended Practice.
In summary, no useful purpose is served in requiring the Contractor to submit a concurrent delay analysis as a precondition to submitting a TIA. This requirement adds a ‘forensic-like’ complexity to what is intended to be a quick and easy process, creating a technical barrier to accomplishing the TIA task. Additionally, a prudent Owner will have to reproduce this concurrent delay analysis from the Owner’s prospective and negotiate a consensus. Concurrent delay analysis is not an integral part of a TIA and should be deferred until after the number of excusable delay days is resolved.

**Comparison of Calculated Results with Actual Observance**

TIA is not an attempt to simulate reality, only to approximate it. It is a recognized analytical technique intended to facilitate a reasonable estimate of the time delay to the project caused by a single delay or a discrete series of delays. To illustrate this point, consider an example where the impact may be judged to involve 3 days while it actually only required 2 days to complete with acceleration. The correct value to use in the TIA would be 3 days, as the saved duration was counter-balanced by the increased costs of acceleration. By using 3 days in this example, the issue of acceleration is eliminated.

It is not reasonable to require that a delay modeled in a TIA manifest itself in that exact number of days that a project actually ends up being late. This is partially due to the extenuating effects of acceleration and mitigation. In addition, other delays (including the Contractor’s own inefficiency) may also contribute to actual late project completion. Mitigation and acceleration efforts by either, or both the Contractor and Owner, may mitigate the actual impact on the project completion date as well. In practically all cases, a construction project will experience enough deviations from the planned baseline schedule so as to make the manifestation of any single delay unattributable to any particular day at the planned end of the project.

Awards of time from a TIA are intended to include the consideration for actual acceleration and disruption in response to a delay. Acceleration and disruption accompanying the delay may be considered to be incorporated in a TIA, and may account for the apparent difference between predicted and actual effects of a delay. While imperfect, the ease and quickness of preparing and reviewing a TIA should compensate for the lack of exactness in modeling the exact features of the impacts to a project due to delay.

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1. ORGANIZATION AND SCOPE

1.1. Introduction

The purpose of the AACE® International Recommended Practice 29R-03 Forensic Schedule Analysis is to provide a unifying reference of basic technical principles and guidelines for the application of critical path method (CPM) scheduling in forensic schedule analysis. In providing this reference, the RP will foster competent schedule analysis and furnish the industry as whole with the necessary technical information to categorize and evaluate the varying forensic schedule analysis methods. The RP discusses certain methods of schedule delay analysis, irrespective of whether these methods have been deemed acceptable or unacceptable by courts or government boards in various countries around the globe.

This RP is not intended to establish a standard of practice, nor is it intended to be a prescriptive document applied without exception. Therefore, a departure from the recommended protocols should not be automatically treated as an error or a deficiency as long as such departure is based on a conscious and sound application of schedule analysis principles. As with any other recommended practice, the RP should be used in conjunction with professional judgment and knowledge of the subject matter. While the recommended protocols contained herein are intended to aid the practitioner in creating a competent work product it may, in some cases, require additional or fewer steps.

AACE recognizes that the method(s) of analysis to be utilized in a given situation, and the manner in which a particular methodology might be implemented, are dependent upon the contract, the facts, applicable law, availability and quality of contemporaneous project documentation, and other circumstances particular to a given situation. Therefore, the RP should be read in its entirety and fully understood before applying or using the information for any purpose. The reader should refrain from using the RP in a manner which is not consistent with its intended use, and not quote any of the contents in an out-of-context manner. As with any other recommended practice published by AACE, this RP is subject to future revisions as new methodologies are identified; new forensic scheduling software is developed; etc.

Forensic1 scheduling analysis refers to the study and investigation of events using CPM or other recognized schedule calculation methods. It is recognized that such analyses may potentially be used in a legal proceeding. It is the study of how actual events interacted in the context of a complex model for the purpose of understanding the significance of a specific deviation or series of deviations from some baseline model and their role in determining the sequence of tasks within the complex network.

Forensic schedule analysis, like many other technical fields, is both a science and an art. As such, it relies upon professional judgment and expert opinion and usually requires many subjective decisions. One of the most important of these decisions is what technical approach should be used to measure or quantify delay and identify the effected activities in order to focus on causation. Equally important is how the analyst should apply the chosen method. The desired objective of this RP is to reduce the degree of subjectivity involved in the current state of the art. This is with the full awareness that there are certain types of subjectivity that cannot be minimized, let alone eliminated. Professional judgment and expert opinion ultimately rest on subjectivity, but that subjectivity must be based on diligent factual research and analyses whose procedures can be objectified.

For these reasons, the RP focuses on minimizing procedural subjectivity. It does this by defining terminology, identifying methodologies currently used by forensic scheduling analysts, classifying them, and setting forth recommended procedural protocols for the use of these techniques. By describing uniform procedures that

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1 The word ‘forensic’ is defined as: 1. Relating to, used in, or appropriate for courts of law or for public discussion or argumentation. 2. Of, relating to, or used in debate or argument; rhetorical. 3. Relating to the use of science or technology in the investigation and establishment of facts or evidence in a court of law: a forensic laboratory. [9] Relating to, or used in debate or argument; rhetorical. 3. Relating to the use of science or technology in the investigation and establishment of facts or evidence in a court of law: a forensic laboratory. [9]
increase the transparency of the analytical method and the analyst’s thought process, the guidelines set forth herein will increase both the accountability and the testability of an opinion and minimize the need to contend with “black-box” or “voodoo” analyses.

Implementation of this RP should result in minimizing disagreements over technical implementation of accepted techniques and allow the providers and consumers of these services to concentrate on resolving disputes based upon substantive, factual and legal issues.

1.2. Basic Premise and Assumptions

a. Forensic scheduling is a technical field that is associated with, but distinct from, project planning and scheduling. It is not just a subset of planning and scheduling.

b. Procedures that may be sufficient for the purpose of project planning, scheduling, and controls may not necessarily be adequate for forensic schedule analysis.

c. It is assumed that this document will be used by practitioners to foster consistency of practice and be used in the spirit of intellectual honesty.

d. All methods are subject to manipulation as they all involve judgment calls by the analyst whether in preparation or in interpretation.

e. No forensic schedule analysis method is exact. The level of accuracy of the answers produced by each method is a function of the quality of the data used therein, the accuracy of the assumptions, and the subjective judgments made by the forensic schedule analyst.

f. Schedules are a project management tool that, in and of themselves, do not demonstrate root causation or responsibility for delays. Legal entitlement to delay damages should be distinct and apart from the forensic schedule analysis methodologies contained in this RP.

1.3. Scope and Focus

The scope and focus of this RP are:

a. This RP covers the technical aspects of forensic schedule analysis methods. It identifies, defines, and describes the usage of various forensic schedule analysis methods in current use. It is not the intent of the RP to exclude or to endorse any method over others. However, it offers caveats and considerations for usage and cites the best current practices and implementation for each method.

b. The focus of this document is on the technical aspects of forensic scheduling as opposed to the legal aspects. This RP is not intended to be a primary resource for legal factors governing claims related to scheduling, delays, and disruption. However, relevant legal principles are discussed to the extent that they would affect the choice of techniques and their relative advantages and disadvantages.

c. Accordingly, the RP primarily focuses on the use of forensic scheduling techniques and methods for factual analysis and quantification as opposed to assignment of delay responsibility. This, however, does not preclude the practitioner from performing the analysis based on certain assumptions regarding liability.

d. This RP is not intended to be a primer on forensic schedule analysis. The reader is assumed to have advanced,
hands-on knowledge of all components of CPM analysis and a working experience in a contract claims environment involving delay issues.

e. This RP not intended to be an exhaustive treatment of CPM scheduling techniques. While the RP explains how schedules generated by the planning and scheduling process become the source data for forensic schedule analysis, it is not intended to be a manual for basic scheduling.

f. This RP is not intended to override contract provisions regarding schedule analysis methods or other mutual agreement by the parties to a contract regarding the same. However, this is not an automatic, blanket endorsement of all methods of delay analysis by the mere virtue of their specification in a contract document. It is noted that contractually specified methods often are appropriate for use during the project in a prospective mode but may be inappropriate for retrospective use2.

g. It is not the intent of this RP to intentionally contradict or compete with other similar protocols3. All efforts should be made by the user to resolve and reconcile apparent contradictions. AACE requests and encourages all users to notify AACE and bring errors, contradictions, and conflict to its attention.

h. This RP deals with CPM-based schedule analysis methods. It is not the intent of the RP to exclude analyses of simple cases where explicit CPM modeling may not be necessary, and mental calculation is adequate for analysis and presentation. The delineation between simple and complex is admittedly blurry and subjective. For this purpose, a ‘simple case’ is defined as any CPM network model that can be subjected to mental calculation whose reliability cannot be reasonably questioned and allows for effective presentation to lay persons using simple reasoning and intuitive common sense.

i. Finally, the RP is an advisory document to be used in conjunction with professional judgment based on working experience and knowledge of the subject matter. It is not intended to be a prescriptive document that can be applied without exception. When used as intended, this RP will aid the practitioner in creating a competent work product, but some cases require additional steps and some require less. Thus, a departure from the recommended protocols should not be automatically treated as an error or a deficiency as long as such departure is based on a conscious and sound application of schedule analysis principles.

1.4. Taxonomy and Nomenclature

The industry knows the forensic schedule analysis methods and approaches described herein by various common names. Current usage of these names throughout the industry is loose and undisciplined. It is not the intent of this document to enforce more disciplined use of the common names. Instead, the RP will correlate the common names with a taxonomic classification. This taxonomy will allow for the freedom of regional, cultural, and temporal differences in the use of common names for these methods.

The RP correlates the common names for the various methods to taxonomic names much like the biosciences use Latin taxonomic terms to correlate regionally diverse common names of plants and animals. This allows the common variations in terminology to coexist with a more objective and uniform language of technical classification. For example, the implementation of method implementation protocol (MIP) 3.7 (aka “TIA”) has a bewildering array of regional variations. Not only that, the method undergoes periodic evolutionary changes while maintaining the same name.

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2 For example, the prospective mode of “Time Impact Analysis” method that inserts estimated delay fragnets into the current schedule update for the purpose of contemporaneously demonstrating entitlement to time extensions.

3 The only other similar protocol known at this time is the “Delay & Disruption Protocol” issued in October 2002 by the Society of Construction Law of the United Kingdom [1]. The DDP has a wider scope than this RP.
By using taxonomic classifications, the RP allows the discussion of the various forensic analysis methods to become more specific and objective. Thus, the RP will not provide a uniform definition for the common names of the various methods, but it will instead describe in detail the taxonomic classification in which they belong. Figure 1 – Nomenclature Correspondence shows the commonly associated names for each of the taxonomic classifications.

The RP’s taxonomy is a hierarchical classification system of known methods of schedule impact analysis techniques and methods used to analyze how delays and disruptions affect entire CPM networks. For example, methods like the window analysis and collapsed as-built are included in the taxonomy, while procedures such as fragnet modeling, bar charting, and linear graphing are not included. Procedures are tools, not methods, and therefore are not classified under this taxonomy.

The taxonomy is comprised of five layers: timing, basic and specific methods, and the basic and specific implementation of each method. Please refer to Figure 2 – Taxonomy of Forensic Schedule Analysis for a graphic representation of the taxonomy. The elements of the diagrams are explained below.

Footnotes
1. Contemporaneous or Modified / Reconstructed
2. The single base can be the original baseline or an update

Figure 1 – Nomenclature Correspondence (see enlarged size figure in Appendix A)

Figure 2 – Taxonomy of Forensic Schedule Analysis (see enlarged size figure in Appendix B)
A. Layer 1: Timing

The first hierarchy layer distinguishes the timing of when the analysis is performed consisting of two branches: prospective and retrospective.

1. **Prospective** analyses are performed in real-time prior to the delay event or in real-time, contemporaneous with the delay event. In all cases prospective analysis consists of the analyst’s best estimate of future events. Prospective analysis occurs while the project is still underway and may not evolve into a forensic context. Since this RP focuses only on forensic schedule analyses, true prospective schedule analysis methods are not discussed. While some of the methods discussed in this RP employ forward looking calculations they are still performed after the project is completed and are therefore considered retrospective.

2. **Retrospective** analyses are performed after the delay event has occurred and the impacts are known. The timing may be soon after the delay event but prior to the completion of the overall project, or after the completion of the entire project. Note that forward-looking analyses (such as ‘additive modeling’) performed after project completion are still retrospective in terms of timing. What is classified here is the real-time point-of-view of the analyst and not the method of analysis). In other words even forward-looking analysis methods implemented retrospectively have the full benefit of hindsight at the option of the analyst.

This distinction in timing is one of the most significant factors in the choice of methods. For example, contract provisions prescribing methods of delay analysis typically contemplate the preparation of such analyses in the prospective mode in order to facilitate the evaluation of time extensions. Therefore, a majority of contractually specified methods, often called “TIA” (MIP 3.7), consists of the insertion of delay events into the most current schedule update that existed at the time of the occurrence of the event: a prospective, forward-looking method.

At the end of the project the choices of analysis methods are expanded with the full advantage of hindsight offered by the various forms of as-built documentation. In addition, if as-built documentation is available, the best evidence rule demands that all factual investigations use the as-built as the primary source of analysis.

Also the timing distinction is often mirrored by a change in personnel. That is, often the forensic schedule analyst who typically works in the retrospective mode is not the same person as the project scheduler who worked under the prospective mode.

B. Layer 2: Basic Methods

The second hierarchy layer is the basic method consisting of two branches: observational and modeled. The distinction drawn here is whether the analyst’s expertise is utilized for the purpose of interpretation and evaluation of the existing scheduling data only, or for constructing simulations and the subsequent interpretation and evaluation of the different scenarios created by the simulations. The distinction between the two basic methods becomes less defined in cases where the identity of the forensic analyst and the project scheduler rest in the same person.

1. **Observational**

The observational method consists of analyzing the schedule by examining a schedule, by itself or in comparison with another, without the analyst making any changes to the schedule to simulate any specific scenario.
Contemporaneous period analysis and as-built vs. as-planned are common examples that fall under the observational basic method.

2. Modeled

Unlike the observational method, the modeled method calls for intervention by the analyst beyond mere observation. In preparing a modeled analysis the analyst inserts or extracts activities representing delay events into or from a CPM network and compares the calculated results of the ‘before’ and ‘after’ states.

Common examples of the modeled method are the collapsed as-built, time impact analysis, and the impacted as-planned.

C. Layer 3: Specific Methods

At the third layer are the specific methods.

1. Observational Methods

Under the observational method, further distinction is drawn on whether the evaluation considers just the original schedule logic or the additional sets of progressive schedule logic that were developed during the execution of the project, often called the dynamic logic.

a. Static Logic Observation

A specific subset of the observational method, the static logic variation compares a plan consisting of one set of network logic to the as-built state of the same network. The term ‘static’ refers to the fact that observation consists of the comparison of an as-built schedule to just one set of as-planned network logic.

The as-planned vs. as-built is an example of this specific method.

b. Dynamic Logic Observation

In contrast with the static logic variation, the dynamic logic variation typically involves the use of schedule updates whose network logic may differ to varying degrees from the baseline and from each other. This variation considers the changes in logic that were incorporated during the project.

The contemporaneous period analysis is an example of this specific method. Note that this category does not occur under the prospective timing mode because the use of past updates indicates that the analysis is performed using retrospective timing.

2. Modeled Methods

The two distinctions under the modeled method are whether the delays are added to a base schedule or subtracted from a simulated as-built.

a. Additive Modeling

The additive modeling method consists of comparing a schedule with another schedule that the analyst has created by adding schedule elements (i.e. delays) to the first schedule for the purpose of modeling a certain scenario.
The additive modeling methods include the impacted as-planned and some forms of the window analysis method. The MIP 3.6 (aka “TIA”) can also be classified as an additive modeling method. This term or its equivalent, time impact evaluation (TIE), has been used in contracts and specifications to refer to other basic and specific methods as well.

b. Subtractive Modeling

The subtractive modeling method consists of comparing a CPM schedule with another schedule that the analyst has created by subtracting schedule elements (i.e. delays) from the first schedule for the purpose of modeling a certain scenario.

The collapsed as-built is one example that is classified under the subtractive modeling method.

D. Layer 4: Basic Implementation

The fourth layer consists of the differences in implementing the methods outlined above. The static logic method can be implemented in a gross mode or periodic mode. The dynamic logic method can be implemented as contemporaneous: as-is, contemporaneous split, contemporaneous modified, or recreated. The additive or subtractive modeling method can be implemented as a single base with simulation or a multiple base with simulation.

1. Gross Mode or Periodic Mode

The first of the two basic implementations of the static logic variations of the observational method is the gross mode. Implementation of the gross mode considers the entire project duration as one whole analysis period without any segmentation.

The alternate to the gross mode is the periodic mode. Implementation of the periodic mode breaks the project duration into two or more segments for specific analysis focusing on each segment. Because this is an implementation of the static logic method, the segmented analysis periods are not associated with any changes in logic that may have occurred contemporaneously with these project periods.

2. Contemporaneous / As-Is or Contemporaneous / Split

This basic implementation pair occurs under the dynamic logic variation of the observation method. Both choices contemplate the use of the schedule updates that were prepared contemporaneously during the project. However the as-is implementation evaluates the differences between each successive update in its unaltered state, while the split implementation bifurcates each update into the pure progress and the non-progress revisions such as logic changes.

The purpose of the bifurcation is to isolate the schedule slippage (or recovery) caused solely by work progress based on existing logic during the update period from that caused by non-progress revisions newly inserted (but not necessarily implemented) in the schedule update.

3. Modified or Recreated

This pair, also occurring under the dynamic logic variation of the observational method, involves the observation of updates. Unlike the contemporaneous pair, however, this implementation involves extensive modification of the contemporaneous updates, as in the modified implementation, or the recreation of entire updates where no contemporaneous updates exist, as in the recreated implementation.
4. Single Base, Simulation or Multi-Base, Simulation

This basic implementation pair occurs under the additive and the subtractive modeling methods. The distinction is whether when the modeling (either additive or subtractive) is performed, the delay activities are added to or extracted from a single CPM network or multiple CPM networks.

For example, a modeled analysis that adds delays to a single baseline CPM schedule is a single base implementation of the additive method, whereas one where delays are extracted from several as-built simulations is a multi-base simulation implementation of the subtractive method.

A single base additive modeling method is typically called the impacted as-planned. Similarly the single simulation subtractive method is called the collapsed as-built. The multi-base, additive simulation variation is often called a window analysis.

The nine method implementation protocols (MIP) in Section 3 represent the instances of basic protocols based on the distinctions outlined in Layer 4.

E. Layer 5: Specific Implementation

1. Fixed Periods vs. Variable Periods / Grouped Periods

These specific implementations are the two possible choices for segmentation under all basic implementations except gross mode and the single base / simulation basic implementations. They are not available under the gross mode because the absence of segmentation is the distinguishing feature of the basic gross mode. They are not available under the single base / simulation basic implementation because segmentation assumes a change in network logic for each segment; the single base simulation uses only one set of network logic for the model.

In the fixed period specific implementation, the periods are fixed in date and duration by the data dates used for the contemporaneous schedule updates, usually in regular periods such as monthly. Each update period is analyzed. The act of grouping the segments for summarization after each segment is analyzed is called blocking.

The variable period/grouped period specific implementation establishes analysis periods other than the update periods established during the project by the submission of regular schedule updates. The grouped period implementation groups together the pre-established update periods while the variable period implementation establishes new periods whose lines of demarcation may not coincide with the data dates used in the pre-established periods and/or which can be determined by changes in the critical path or by the issuance of revised or recovery baseline schedules. This implementation is one of the primary distinguishing features of the variable period analysis method.

2. Global (Insertion or Extraction) vs. Stepped (Insertion or Extraction)

This specific implementation pair occurs under the single base, simulation basic implementation, which in turn occurs under the additive modeling and the subtractive modeling specific methods. Under the global implementation delays are either inserted or extracted all at once, while under the stepped implementation, the insertion or the extraction is performed sequentially (individually or grouped).

Although there are further variations in the sequence of stepping the insertions or extractions, usually the insertion sequence is from the start of the project towards the end, whereas stepped extraction starts at the end and proceeds towards the start of the project.
1.5. Underlying Fundamentals and General Principles

A. Underlying Fundamentals

At any given point in time on projects, certain work must be completed at that point in time so the completion of the project does not slip later in time. The industry calls this work, “critical work.” Project circumstances that delay critical work will extend the project duration. Critical delays are discrete, happen chronologically, and accumulate to the overall project delay at project completion.

When the project is scheduled using CPM scheduling, the schedule typically identifies the critical work as the work that is on the “longest” or “critical path” of the schedule’s network of work activities. The performance of non-critical work can be delayed for a certain amount of time without affecting the timing of project completion. The amount of time that the non-critical work can be delayed is “float” or “slack” time referring to as Total Float.

A CPM schedule for a particular project generally represents only one of the possible ways to construct the project. Therefore, in practice, the schedule analyst must also consider the assumptions (work durations, logic, sequencing, and labor availability) that form the basis of the schedule when performing a forensic schedule analysis. This is particularly true when the schedule contains preferential logic (i.e., sequencing which is not based on physical or safety considerations) and resource assumptions. This is because both can have a significant impact on the schedule’s calculation of the critical path and float values of non-critical work at a given point in time.

CPM scheduling facilitates the identification of work as either critical or non-critical. Thus, at least in theory, CPM schedules give the schedule analyst the ability to determine if a project circumstance delays the project or if it just consumes float in the schedule assuming that float is not specifically owned by either party under that terms of the contract. For this reason, delay evaluations utilizing CPM scheduling techniques are preferred for the identification and quantification of project delays.

The critical path and float values of uncompleted work activities in CPM schedules change over time as a function of the progress (or lack of progress) on the critical and non-critical work paths in the schedule network. Only project circumstances that delay work that is critical when the circumstances occur extend the overall project. Thus, when quantifying actual project delay, the accuracy in quantification is increased when the impacts of potential causes of delay are evaluated within the context of the schedule in effect at the time when the impacts happen.

B. General Principles

1. Use CPM Calculations

Calculation of the critical path and float must be based on a CPM schedule with proper logic (see Subsection 2.1.)

2. Concept of Data Date Must be Used

The CPM schedule used for the calculation must employ the concept of the data date or status date. Note that the critical path and float can be computed by commonly available commercial CPM software only for the portion of the schedule forward (future) of the data date.

3. Shared Ownership of Network Float
In the absence of contrary contractual language, network float, as opposed to project float, is a shared commodity between the owner and the contractor. In such a case float must be shared in the interest of the project rather than to the sole benefit of one of the parties to the contract.

4. Update Float Preferred Over Baseline Float

If validated, contemporaneous updates exist, relative float values for activities in those updates at the time the schedule activity was being performed are considered more reliable compared to relative float values in the baseline for those same activities.

5. Sub-Network Float Values

What is critical in a network model may not be critical when a part of that network is evaluated on its own, and vice versa. The practical implication of this rule is that what is considered critical to a subcontractor in performing its own scope of work may not be critical in the master project network. Similarly, a schedule activity on the critical path of the general contractor’s master schedule may carry float on a subcontractor’s sub-network when considered on its own.

6. Delay Must Affect the Critical Path

In order for a claimant to be entitled to an extension of contract time for a delay event (and further to be considered compensable), the delay must affect the critical path. This is because before a party is entitled to time-related compensation for damages it must show that it was actually damaged. Because conventionally a contractor’s delay damages are a function of the overall duration of the project, there must be an increase in the duration of the project.

7. All Available Schedules Must Be Considered

Regardless of the method selected for analysis, all available sources of planning and schedule data created during the project, including but not limited to, various versions of baselines, updates and as-builds, should be examined and considered, even if they are not directly used for the analysis.

2. SOURCE VALIDATION

The intent of the source validation protocols (SVP) is to provide guidance in the process of assuring the validity of the source input data that forms the foundation of the various forensic schedule analysis methodologies discussed in Section 3. Any analysis method, no matter how reliable and meticulously implemented, can fail if the input data is flawed. The primary purpose of the SVP is to minimize the failure of an analysis method based upon the flawed use of source data.

The approach of the SVP is to maximize the reliable use of the source data as opposed to assuring the underlying reliability or accuracy of the substantive content of the source data. The best accuracy that an analyst can hope to achieve is in the faithful reflection of the facts as represented in contemporaneous project documents, data, and witness statements. Whether that reflection is an accurate model of reality is almost always a matter of debatable opinion.

Source validation protocols consist of the following:

2.1. Baseline Schedule Selection, Validation, and Rectification (SVP 2.1)
2.2. As-Built Schedule Sources, Reconstruction, and Validation (SVP 2.2)
2.3. Schedule Updates: Validation, Rectification, and Reconstruction (SVP 2.3)
2.4. Identification and Quantification of Discrete Impact Events and Issues (SVP 2.4)

2.1. Baseline Schedule Selection, Validation, and Rectification (SVP 2.1)

A. General Considerations

The baseline schedule is the starting point of most types of forensic schedule analyses. Even methods that do not directly use the baseline schedule, such as the modeled subtractive method, often refer to the baseline for activity durations and initial schedule logic. Hence, assuring the validity of the baseline schedule is one of the most important steps in the analysis process.

Note that validation for forensic purposes may be fundamentally different from validation for purposes of project controls. What may be adequate for project controls may not be adequate for forensic scheduling, and vice versa. Thus, the initial focus here is in assuring the functional utility of the CPM baseline schedule for purpose of analysis as opposed to assuring the reasonableness of the information that is represented by the data or optimization of the schedule logic. Functional utility refers to the usefulness of the schedule data for quantitative, CPM-based calculations as opposed to a more subjective, qualitative assessment of the reasonableness of the baseline schedule. So, for example, the validation of activity durations against quantity estimates is probably not something that would be performed as part of this protocol. The test is that if it is possible to build the project in the manner indicated in the schedule and still be in compliance with the contract, then do not make any subjective changes to improve it or make it more reasonable.

The obvious exception to the above would be where the explicit purpose of the investigation is to evaluate the reasonableness of the baseline schedule for planning, scheduling and project control purposes. For those guidelines please refer to other Recommended Practices published by AACE^4.

The recommended protocol outlined below assumes that the forensic analysis contemplates the investigation of schedule deviations at Level 3 (sufficient detail to monitor and manage the overall project) degree of detail^5. The user is cautioned that an investigation of schedule deviations at Level 1 or 2 may require less detail. Similarly, investigation of schedule deviations at Level 4 may require verification at a higher level of detail.

The recommended protocol below is worded as a set of investigative issues that should be addressed. If the baseline schedule is to be used in an observational analysis, the forensic schedule analyst may simply note the baseline’s schedule’s compliance or non-compliance with the various protocols below. If however, the baseline schedule is to be used in a modeled analysis, the various protocols below form the basis for documented alterations so that the adjusted baseline schedule both reflects its original intent as closely as possible and still meets the procedural elements of the recommended protocol.

SVP 2.1 also forms the basis of SVP 2.3, which deals with the validation and rectification of schedule updates, since early updates are based almost entirely on the baseline schedule.

B. Recommended Protocol

CAVEAT: When implementing MIPs 3.3 or 3.4, baseline validation protocols involving changes to logic or calendars should not be implemented.

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^4 AACE International’s Planning & Scheduling Committee is developing an RP that includes an extensive discussion on the baseline schedule.
^5 Refer to AACE International Recommended Practice No. 37R-06 Schedule Levels of Detail: As Applied in Engineering, Procurement and Construction for additional information.
1. Ensure that the baseline schedule is the earliest, conformed plan for the project. If it is not the earliest, conformed plan, be prepared to identify the significant differences and the reasons why the earliest, conformed plan is not being used as the baseline schedule.

2. Ensure that the work breakdown and the level of detail are sufficient for the intended analysis.

3. Ensure that the data date is set at notice-to-proceed (or earlier) with no progress data for any schedule activity that occurred after the data date.

4. Ensure that there is at least one continuous critical path, using the longest path criterion that starts at the earliest occurring schedule activity in the network (start milestone) and ends at the latest occurring schedule activity in the network (finish milestone).

5. Ensure that all activities have at least one predecessor, except for the start milestone, and one successor, except for the finish milestone.

6. Ensure that the full scope of the project/contract is represented in the schedule.

7. Investigate and document the basis of any milestones dates that violate the contract provisions.

8. Investigate and document the basis of any other aspect of the schedule that violates the contract provisions.

9. Document and provide the basis for each change made to the baseline for purposes of rectification.

10. Ensure that the calendars used for schedule calculations reflect actual working day constraints and restrictions actually existing at the time when the baseline schedule was prepared.

11. Document and explain the software settings used for the baseline schedule.

C. Recommended Enhanced Protocol

CAVEAT: When implementing MIP 3.3 or 3.4, baseline validation protocols involving changes to logic or calendars should not be implemented.

1. The level of detail is such that no single schedule activity (other than a milestone activity created solely for the purpose of payment) carries a contract payment value of more than one half of one percent (½%) of total contract payment value per unit of activity duration, and no more than five percent (5%) of total contract payment value per schedule activity.

2. Create separate activities for each responsible party.

3. Document the basis of all controlling and non-controlling constraints.

4. Replace controlling constraints, except for the start milestone and the finish milestone, with logic and/or activities.

5. Because delay scenarios often involve factors external to the original contract assumptions when the baseline was created, it may be necessary to add activities or enhance the level of detail beyond that contained in the baseline.
6. If the description of the schedule activity is too general or vague to properly ascertain the scope, the schedule activity should be subdivided into detailed components using other progress records.

D. Special Procedures

1. Summarization of Schedule Activities

a. If the level of detail of the baseline is clearly excessive in comparison to the delays being evaluated, the analyst may choose to summarize the baseline schedule for purposes of analysis. In doing so, the following guidelines are recommended:

b. Restrict the summarization of activities that fall on the critical or near-critical paths to only those situations where the available as-built data do not correspond with the activity breakdown and/or the activity descriptions of the baseline schedule.

c. Organize the full-detail source schedule so that the identity of the activities comprising the summary schedule activity can be determined using:

   i. Summarizing or hammocking.
   ii. Work breakdown structure (WBS).
   iii. Coding of the detail activities with the summarized activity ID.

d. Restrict the summarization to logical chains of activities with no significant predecessor or successor logic ties to activities outside of the summarized detail.

e. Restrict the summarization to logical chains of activities that are not directly subject to delay impact evaluation or modeling.

2. Reconstruction of a Computerized CPM Model from a Hardcopy

a. The recommended set of hardcopy data necessary for an accurate reconstruction is:

   i. Predecessor & successor listing with logic type and lag duration, preferably sorted by activity ID.
   ii. Tabular listing of activities showing duration, calendar ID, early and late dates, preferably sorted by activity ID.
   iii. Detailed listing of working days for each calendar used.

b. The recommended level of reconstruction has been reached when the reconstructed model and the hardcopy show matching data for:

   i. Early start & early finish.
   ii. Late start & late finish.

c. A graphic logic diagram alone is not a reliable hardcopy source to reconstruct an accurate copy of a schedule.
3. De-Statusing a Progressed Schedule to Create a Baseline

If a baseline schedule is not available, but a subsequent CPM update exists, the progress data from the update can be removed to create a baseline schedule. Also, the schedule that is considered to be the baseline schedule may contain some progress data or even delays that occurred prior to the preparation or the acceptance of the baseline schedule. The general procedure consists of the following:

a. For each schedule activity with any indicated progress, remove actual start (AS) and actual finish (AF) dates.

b. For each schedule activity with any indicated progress, set completion percentage to 0%.

c. For each schedule activity with any indicated progress, set remaining duration (RD) equal to original duration (OD).
   i. The OD should be based on the duration that was thought to be reasonable at the time of NTP. If the update is one that was prepared relatively early in the project, it is likely that the OD is the same as the OD used in the baseline schedule.

   ii. The OD should not be based on the actual duration of the schedule activity from successive updates.

d. Set the schedule data date (DD) to the start of the project, usually the notice-to-proceed or some other contractually recognized start date.

e. Review the scope of the progressed schedule to determine whether it contains additions to or deletions from the base contract scope. If so, modify the schedule so it reflects the base contract scope.

4. Software Format Conversions

a. Document the exact name, version, and release number of the software used for the source data which is to be converted.

b. If available, use a built-in automatic conversion utility for the initial conversion and compare the recalculated results to the source data for:
   i. Early start & early finish.

   ii. Late start & late finish.

c. Manually adjust for an exact match of the early and late dates by adjusting:
   i. The lag value of a controlling predecessor tie and the calendar assigned to the lag value, if necessary.

   ii. The relationship type of a controlling predecessor tie.

   iii. Activity duration.

   iv. Constraint type and/or date.
d. Document all manual adjustments made and explain and justify if those adjustments have a significant effect on the network.

2.2. As-Built Schedule Sources, Reconstruction, and Validation (SVP 2.2)

A. General Considerations

Along with the baseline schedule, the as-built schedule, more specifically the as-built schedule data, is one of the most important source data for most types of forensic schedule analysis methods. Even methods that do not directly use the as-built schedule, such as the modeled additive methods, often refer to the as-built schedule data to test the reasonableness of the model. As with the baseline, assuring the validity of the as-built schedule data is one of the most important steps in the analysis process.

It is important to accept the fact that the accuracy and the reliability of as-built data are never going to be perfect. Rather than insisting on increasing the accuracy, it is better to recognize uncertainty and systematize the measurement of the level of uncertainty of the as-built data and document the source data. One of the simplest systems is to call all uncertainty in favor of the adverse party. However, it may be more defensible to use a set of consistent set of documentation for the as-built. Of course the most reasonable solution may be for both parties to agree on a set of as-built dates prior to proceeding with the analysis and the resolution of the dispute.

There are two different approaches to creating an as-built schedule. The first one is to create an as-built schedule from scratch using various types of progress records, for example, the daily log. The resulting schedule is defined by and potentially constrained by the level of detail and the scope of information available in the project records used to reconstruct the as-built.

The second approach is to adopt the fully progressed update as the basic as-built schedule and modify or augment it as needed. Often a fully progressed update is not available and the analyst must complete the statusing of the schedule using progress records. A subset of this approach is to create a fully progressed baseline schedule from progress records. In implementing this approach it is important to understand the exact scope of the activities in the baseline schedule before verifying or researching the actual start and finish dates.

The subtractive modeling methods require an as-built schedule with complete logic as the starting point. Note that the preparation of the model requires not only the validation of as-built dates but also the simulation of an as-built schedule based on actual durations, logic and lags.

To qualify as an as-built schedule, the cause of delays need not be explicitly shown so long as the delay effect is shown. For example, if a scheduled activity that was planned to be completed in ten days but took thirty days and is shown as such, the cause of the delay need not be shown for it to be a proper as-built. However, as the analysis progresses, eventually the delay causation would need to be addressed and made explicit in some form. Note that if the analyst chooses to explicitly show delays, SVP 2.4 covers the subject of identification and quantification of delays.

In most cases the as-built schedule is a fully statused scheduled with a data date equal to or later than the actual completion date of the project. However, the term “as-built” may also be used to describe the most recent schedule update. In this case, only the activities which are statused to the left of the data date are considered “as-built” data. Consequently it is possible to perform a comparative as-built analysis, such as MIP 3.1, prior to the actual completion of the overall project, as long as the delaying events and its effects have all occurred prior to the data date.
The as-built critical path cannot be directly determined using conventional float calculation on the past portion (left) of the data date. Because of this technical reason, often the critical set of as-built activities is called the controlling activities as opposed to critical activities.

Objective identification of the controlling activities is difficult, if not impossible, without the benefit of any schedule updates or at least a baseline CPM schedule with logic. Therefore, in the absence of competent schedule updates, the analyst must err on the side of over-inclusion in selecting the controlling set of as-built activities. The determination must be a composite process based on multiple sources of project data including the subjective opinion of the peripient witnesses.

Contemporaneous perception of criticality by the project participants is just as important as the actual fact of criticality because important project execution decisions are often made based on perceptions. For more on the subject of Identifying the As-Built Critical Path, refer to Subsection 4.3.C.

The recommended protocol outline below assumes that the forensic analysis contemplates the investigation of schedule deviations at Level 3 (project controls) degree of detail. The user is cautioned that an investigation of schedule deviations at Level 1 or 2 may require less detail. Similarly, an investigation of schedule deviations at Level 4 may require verification at a higher level of detail.

B. Recommended Protocol

1. If a schedule update is the primary source of as-built schedule data:
   a. Ensure that the data date is set equal to or later than the events and impacts that are to be evaluated in the analysis.
   b. Ensure that all activities to the left of the data date have actual start and completion dates.
   c. Ensure that all activities to the right of the data date do not have actual start or finish dates.
   d. Perform a check of the as-built dates using the source deemed most reliable other than the update itself.
   e. If possible, interview the project scheduler or other persons most knowledgeable for updated data collection and data entry procedures to evaluate the reliability of the statusing data.
   f. Determine and allow for whether significant changes have been made to activity descriptions and IDs.
   g. Understand the exact scope and assumptions underlying the schedule activities so that the as-built data is a reflection of the same scope and assumptions.

2. Perform a check of all critical and near-critical activities as defined by this RP and a random 10% sampling of all activities against the reliable alternate source to determine whether a more extensive check is necessary. Note that this step may have to be repeated as ongoing analysis warrants the inclusion of more activities as critical or near-critical than originally identified.

3. Dates of significant activities should be accurate to 1 working day and dates of all other activities should be accurate to 5 working days or less.

4. Contractual dates such as notice-to-proceed, milestones, and completion dates should be accurate to the exact date. Should those dates be subject to dispute, the justification for the selection of the dates should
be clearly stated.

C. Recommended Enhanced Protocol

1. Tabulate all sources of as-built schedule data and evaluate each for reliability.

2. If a baseline schedule exists and where a direct comparison between the baseline and the as-built would be difficult due to changes in activity IDs, descriptions, and/or software packages, an “as-built” can be created by fully progressing the planned activities allowing for a one-to-one planned versus actual comparison of each baseline schedule activity. See Subsection 2.2.D.2.

3. Show discrete activities for delay events and delaying influences.

4. If the description of the schedule activity is too general or vague to properly ascertain the scope, the schedule activity should be subdivided into detailed components using other progress records.

D. Special Procedures

1. Creating an Independent As-Built from Scratch “Daily Specific As-Built” (DSAB)

   a. An as-built record of the work on a project is often necessary to verify the accuracy of the CPM dates reflected in the various schedule updates and to identify and correlate events inside a single CPM schedule activity. This identification of events inside a CPM schedule activity is essential to particularize possible shifts in the schedule and explain responsibility for any delays.

   b. The best source for as-built data is a continuous daily history of events on the project developed and maintained by persons working on the project. Traditionally, there are contractor’s daily reports, but there may also be owner’s daily inspection reports or a scheduler’s daily progress report. These daily records can be augmented as required by other primary sources such as certified payrolls and timesheets, completion certificates, inspection reports, incident reports, and start-up reports. Secondary sources such as weekly meeting minutes or progress reports can also provide insight into what happened.

   c. It is often best to develop the DSAB using a database where every entry in the daily report is separately listed as a record. Such a database would allow for the complete history of each schedule activity over time, or an electronic version of the daily report coded for activities worked on each particular day. Notes on the daily reports such as problems or delays can be listed as additional activities.

   d. It is important to develop a correlation between as-planned activities and as-built activities. Baseline schedule activities usually include descriptions sufficient to distinguish them from other similar activities. The as-built schedule is coded to the same activities included in the baseline schedule. It is frequently the case that there is not a perfect match between the activities of the two schedules. Some of the as-planned activities do not appear in the as-built, and, more frequently, there are significant as-built activities that are either in greater detail than the as-planned or simply do not appear in the as-planned.

      i. *Activity in the baseline schedule, but not the as-built schedule*—There are generally three reasons for an activity to appear in the baseline schedule but not the as-built schedule. The first and most likely reason is that the as-built is not sufficiently detailed. This is usually because the work depicted in detail in the baseline schedule is described more generically in the as-built. In this
case, the preferred method would be to divide the as-built activity into two constituent parts if contemporaneous notes permit. If this is not possible, then the two represented activities in the baseline schedule should be combined. The second reason could be that the schedule activity was deleted by change order and thus does not appear in the as-built. If this is the case, it is generally not appropriate to modify the baseline schedule. Rather, the lack of an as-built activity will have to be evaluated in light of successor work. The third reason rarely occurs: The contractor may not have performed a specific aspect of the work, even though it is required. In such a situation the longer duration of the predecessor or successor must be considered in light of the “missing” schedule activity.

ii. **Activities in the as-built schedule, but not the baseline schedule --There generally are** three reasons for an activity appearing in the as-built schedule but not the baseline schedule. The first and most likely possibility is that the actual activity is simply reported in more detail in the as-built than in the as-planned. In this situation, it is generally better to combine the more detailed as-built data into a schedule activity that is reflected in the as-planned. However, this extra detail from the as-built may be necessary in performing a responsibility analysis. The second reason could be that the activity was new—it was added by a change order. If this is the case, it is generally again not appropriate to modify the baseline schedule. Rather, the new as-built activity should be treated simply as additional work and coded in such a manner as to indicate this situation and permit the analysis to properly consider it. The third reason is that the baseline schedule might not completely reflect the actual scope of contractual work. Again, it is probably best not to alter the baseline schedule but rather to reflect the actual work activity in its proper logical as-built sequence. This should not occur if the analysis is utilizing a properly validated baseline schedule (see SVP 2.1).

e. Line up the as-built and baseline schedule--This step can be performed either in a large database with graphical output, or can be done in a more personal/mechanical manner by hand.

i. **Using a database**—By using a database, the analyst can arrange or cluster the activities according to whatever sequence seems most appropriate. For example, it may be useful on a multi-building project to review the data by building. Alternatively, if the performance of a particular trade is important, then the review could be performed based on trade. It is possible through export from a database to a graphical program to plot the baseline schedule data (early/late, start/finish) directly against the as-built record.

ii. **By hand. (A.K.A. X-chart or Dot-chart)**—On small projects it is possible to simply plot the data graphically by hand. This technique is called the “X-chart” because the analyst placed an “X” in the appropriate date and activity of a chart with dates along the X-axis and activities along the Y-axis. This pre-computer technique is still useful for smaller projects or partial analysis.

f. Identify the true “start” of an activity—It is usually relatively easy to identify from the as-built data the start of an activity but not always. It is recommended that the start of an activity be considered the first date associated with a series of substantive work days on the activity. Care should be taken in discounting “false starts” or “false finishes” that they do not reflect a true delay. Care should also be taken to ensure that a false start does not actually represent an actual start coupled with a suspension due to a delay event.

g. Identify the true “finish” of an activity—The same logic as above applies to the finish dates. Generally the analyst, absent specific data to the contrary, should assume that when the period of concentrated work is completed on an activity, the activity is complete. Another possible criterion is that an activity can be considered logically complete when a successor tied with a simple FS logic is
able to start substantive work.

2. Creating a Fully Progressed Baseline

a. A fully-progressed version of the baseline schedule allows for a comparison of the plan to actual performance at an individual activity level of detail. Often, however, a progressed baseline is not readily available because the schedule is changed during progress.

b. The most expeditious procedure to create a fully progressed baseline is to use the as-built data for each activity contained in the final update and transfer them to the corresponding baseline activities. In implementing this procedure the analyst must:

i. Recognize that using the activity ID as the sole criterion for correspondence between the final update and the baseline may not be adequate if the activity descriptions are not virtually identical.

ii. Therefore, in addition, the analyst must understand the scope and the assumptions underlying the baseline schedule activities so that the as-built data is a reflection of the same scope and assumptions.

c. The baseline set of activities may have to be summarized to receive the corresponding as-built data if the activities have been summarized in the final update.

d. If the corresponding final update activities are more detailed than the baseline activities, determine the update activity representing the start of the less detailed activity chain in the baseline and the update activity representing the finish of that same chain in order to set the actual start and finish dates.

3. Determination of ‘Significant’ Activities for Inclusion in an As-Built

Many CPM schedules in current use contain hundreds if not thousands of activities. While that level of detail may be necessary to keep track of performance and progress for the purpose of project controls, the facts of the dispute may not require the analysis of each and every activity in a forensic context. This section offers guidelines for streamlining and economizing the as-built analysis process without compromising the quality of the process and the reliability of the results.

Because this step typically occurs early in the analysis process, the analyst may not have a full understanding of the project and the issues. Therefore, the criterion is of *prima facie* significance. In other words, if in doubt, consider it significant. As a result, it is possible that at the end of the analysis some of the selected activities are considered insignificant. But that is better than discovering at the end of the analysis that some significant activities and key factors were not considered. This is a multi-iterative process that requires continuous refinement of the set of significant activities during the analysis process.

The main factor for significance is criticality. The procedure for determining the as-built critical path is discussed in Subsection 4.3.C and the procedure for determining the significant activities includes the procedure set forth in Subsection 4.3.C. However, in addition to those items the following items are recommended for inclusion in the significant set:

- Suspected concurrent delays including those alleged by the opposing party
- Activity paths for which time extensions were granted
• Delay events and all activities on the logical path(s) on which those events lie
• All milestones used in the schedule
• High-value (based on pay loading) activities
• High-effort (based on resource loading) activities

Note that in many cases some significant activities are not discretely and explicitly contained in the CPM model. Obviously, these extraneous activities must also be considered in the as-built.

4. Collapsible As-Built CPM Schedule

The fundamental difference between a fully progressed CPM and a collapsible as-built CPM schedule is in the schedule logic. The fully progressed CPM schedule can graphically illustrate the as-built condition using the actual start and actual finish dates assigned to each schedule activity. However, the schedule cannot be used for calculation because it has been fully progressed. Therefore, the actual activity duration (AD) and the logic ties are no longer controlling the network calculation. On the other hand, the collapsible as-built is a CPM model of the as-built condition. The schedule is revised by assigning actual durations to the activities and tying them together with logical relationships so that the actual start and the actual finish dates are simulated in the schedule as calculated start and finish dates. For a step-by-step procedure please refer to MIP 3.8.

5. Summarization of Schedule Activities

a. If the level of detail of the as-built is clearly excessive in comparison to the delays being evaluated, the analyst may choose to summarize the as-built schedule for purposes of analysis. In doing so, the following guidelines are recommended:

b. Ensure that summarization is restricted to activities that do not fall on the critical or near-critical paths.

c. Organize the full-detail source schedule so that the identity of the activities comprising the summary schedule activity can be determined using:

   i. Summarizing or hammocking.

   ii. Work breakdown structure (WBS).

   iii. Coding the detail activities with the summarized activity ID.

d. Restrict the summarization to logical chains of activities with no significant predecessor or successor logic ties to activities outside of the summarized detail.

e. Restrict the summarization to logical chains of activities that are not directly subject to delay impact evaluation or modeling.

2.3. Schedule Updates: Validation, Rectification, and Reconstruction (SVP 2.3)

A. General Considerations

SVP 2.3 discusses issues involved in evaluating the project schedule updates for use in forensic schedule analysis.
The schedule update consists of the as-built portion on the left side of the data date, the as-planned portion on the right side of the data date, and the data date itself. Because SVP 2.1 addresses the issues relevant to the as-planned portion, and 2.2 addresses the issues relevant to the as-built portion, the focus of SVP 2.3 is on the practice of updating the schedule with progress information and the reliable use of that progress data.

**B. Recommended Protocol**

1. Interview the project scheduler or other persons-most-knowledgeable for updated data collection and data entry procedures to evaluate the reliability of the statusing data.

2. Assemble all schedule updates so that they cover the entire project duration from start to finish or up to the current real-time data date.

3. Use officially submitted schedule updates.

4. Ensure that the update chain starts with a validated baseline.

5. Check on the consistency of the actual start and finish dates assigned to each schedule activity from update to update.

6. For each update, identify all changes made that extend, reduce, or change the longest path or the controlling path to an interim contractual milestone.

7. If other progress records are available, check the remaining duration and percentage complete values for consistency with these other progress records and make.

**C. Recommended Enhanced Protocol**

1. Implement SVP 2.1 for the as-planned portion of each schedule update, including the baseline.

2. Implement Subsection 2.4.D.2. to bifurcate the pure-progress step from the logic revision steps in each update.

**D. Special Procedures**

1. **Reconstructed Updates**

There are two main schools of thought on recreating a partially statused schedule. The first school of thought, called the hindsight method, states that since the forensic scheduler is performing the analysis after the job has been completed, the analyst should use the actual performance dates and durations to recreate the updates.

The second school of thought, called the blinders or the blindsight method, requires the analyst to pretend that the analyst does not have access to actual performance data and simulate the project scheduler’s mindset at the time the update was actually being prepared. Therefore, the analyst needs to consider what the scheduler would have assigned as the remaining duration for that schedule activity at that time. If the analyst does not have reliable access to the scheduler’s contemporaneous bases for assigning remaining durations, the analyst needs to be as objective as possible and follow a remaining duration formula.
Outlined below are the two methods:

a. "Hindsight" Method

In this method, the actual status of the schedule activity in the succeeding schedule update period is used to calculate the remaining duration of the previous schedule update. This is delineated in the formula below:

i. \[ RD = \text{actual duration of succeeding update} - (\text{data date} - \text{actual start of activity}) \] where the data date is the data date of the existing schedule update that needs to be statused.

b. "Blindsight" Method

In this method, it is assumed that the analyst does not have the update schedule for the succeeding period and has no knowledge of the project conditions later than the update under investigation. Therefore, the analyst must stand in the shoes of the scheduler at the time of the project. Note that the progress curve created by this method assumes a straight line.

i. IF: data date (DD) - actual start of the activity (AS) < original duration (OD), THEN: remaining duration (RD) = OD - (DD - AS)

ii. IF: DD - AS > OD, THEN: RD = 1

2. Bifurcation: Creating a Progress-Only Half-Step Update

Bifurcation (aka half-stepping or two-stepping) is a procedure to segregate progress reporting from various non-progress revisions inherent in the updating process. This should not be considered a revision or modification of the update schedules but rather a procedure that examines selected data, namely logic changes isolated by this process, which may be present in the updates of record. For a step-by-step implementation of the bifurcation process refer to MIP 3.4

3. Changing the Contemporaneous Project Schedule for the Analysis

Due to the complex nature of construction projects and the fact that CPM schedules are models of reality, not reality itself, the analyst will inevitably encounter an instance when the contemporaneous project schedule contains an anomaly that could affect the assessment of critical project delay. Instead of completing the analysis using a schedule with an anomaly or entirely abandoning the schedules because of the anomaly, the analyst has the option to correct the anomaly in the contemporaneous project schedule and use the corrected schedule as the basis for the analysis.

Correcting the contemporaneous schedules does not automatically result in a shift in classification of the analytical technique from an analysis based on contemporaneous schedules such as MIP 3.3 (Observational / Dynamic / As Is) to one based on non-contemporaneous schedules such as MIP 3.5 (Observational / Dynamic / Modified or Recreated). However, these changes and how they affect the contemporaneous data, plan, and information reported, should be disclosed by the analyst along with the objective reason for those changes.

Having stated that, the preference of every analyst should be to use the contemporaneous schedules and updates as they were prepared, reviewed, or accepted, and used on the project. This belief is grounded in the fact that the parties used the imperfect schedules to make decisions and manage the project work. Thus, these schedules, even though not perfect, are the best representation of the
parties’ objectives and understanding of the project contemporaneously and are an indicator of each party’s performance. The fact that the contemporaneous schedules were rejected by the owner is not automatically dispositive of their value. This is because where delays are present during the project schedules are often rejected for reasons other than their technical reliability as a schedule, but for reasons of contractual compliance regarding the completion date.

However, absent contract language mandating the use of the contemporaneous schedules to quantify delay, corrections to the contemporaneous schedules can be properly considered by the analyst without eroding the credibility of the resulting analysis. The following is a discussion of examples of revisions to the contemporaneous schedules that may fit within the boundaries of such corrections:

a. Correcting a Wrong Actual Start or Finish Date

Sometimes, the actual start and finish dates recorded in the contemporaneous project schedules may be inaccurate. The analyst may consider relying on other contemporaneous documents to correct these dates. The analyst may limit the correction of the wrong actual start and finish dates to paths of work that have the potential to delay the project and are on critical or near-critical paths. When an analyst chooses to correct a wrong actual date in the schedule, the analyst should be mindful that correcting a date may result in a shift in the critical path. If the project team never recognized that the date was wrong, and relied on the schedule generated by calculations based on that date, the correction should not be made if the focus of the analysis is on the mindset of the team on which decisions were made at the time, as opposed to developing an accurate as-built schedule.

b. Correcting Schedule Anomalies

A schedule anomaly is any feature in the schedule that creates a physically or logically impossible sequence of work or a sequence of work that is not permitted by the conformed contract provisions. These features may include:

i. An incorrect logic relationship
ii. A missing logic relationship
iii. An incorrect activity based on described scope of the activity
iv. A missing activity

If a sequence of work is possible and contractually permitted, it should not be corrected even if, in the opinion of the analyst, there is a ‘better’ way of performing the work. The correction of an anomalous feature can gain enhanced validity if the project participants recognized the anomaly in the schedule contemporaneously and that the anomaly was ultimately corrected by the project team in the contemporaneous project schedules at some point during the project. or recognized and identified as an anomaly in the schedule in a contemporaneous project document.

c. Bringing a Revision Back in Time to Represent Added or Changed Work

This situation occurs when a schedule revision or fragnet (fragmentary network representing added or changed work) was inserted into the contemporaneous project schedules well after the change or event that necessitated the revision occurred. If the schedule revision or fragnet was not inserted into the appropriate contemporaneous project schedule, but was recognized and identified in a contemporaneous project document as a change that should have been made, then the analyst may decide to insert the schedule revision or fragnet into
the contemporaneous schedule update in effect when the change occurred to measure the resulting delay.

This correction involves bringing back (or inserting) the schedule revision or fragnet to the point or nearest the moment in time) when the event occurred. The schedule revision or fragnet that is brought back in time (or inserted) will typically be a duplicate of an existing revision or fragnet that was inserted into the schedule during the project or as described in the contemporaneous project documents. It must be noted that if the fragnet consists of actual durations, and relationships, this procedure would create a hindsight impact simulation as opposed to a blindsight impact simulation, which would be implemented with a fragnet consisting of planned durations and relationships estimated at the time the event occurred.

d. Splitting an Activity

Typically, updates increase in detail as the schedule progresses, therefore the number of activities increase, not necessarily an increase in scope but an increase in detail. When a variance analysis is performed between two updates with different activity counts, exact correlation is not possible since the more detailed activity set did not exist in the previous update. Therefore, the detailed activity set should be replicated in the previous update with the same planning duration, logic and dates of the summary activity.

All of these corrections should be described in the analyst's report along with the basis of the corrections so that the other parties and the fact finders understand the changes that the analyst made to the contemporaneous schedule.

When an analyst concludes that more extensive revisions are necessary to the contemporaneous project schedules than those contemplated in paragraphs a., b., and c., above, such revisions should be made cautiously, consistently, and founded to the greatest extent possible on the contemporaneous project documentation. The analyst must also remember that most schedules are models and, hence, perfection is not the standard.

The issue of correcting the schedule is one of balance and reasonableness and, for these reasons corrections should not be made across the board or automatically.

Note that some significant errors in the underlying analysis schedules may not substantially affect the ultimate conclusions of the analysis. For example, imagine a schedule where a significant activity was omitted. Even though the work is absent from the schedule, it would not necessarily be absent from the analysis. If three activities, A, B, and C, must be performed in sequence, but the schedule leaves out B, the analysis will still detect a delay due to B. This is because C cannot start until B is completed. Any delay attributable to B will show up as a delay to the start of C. There may be no need to “correct” the schedule by adding B into the schedule. Delays to B may be addressed by the analysis even though B is not present.

Finally, the analyst must also be consistent and maintain independence and objectivity. The analyst cannot limit its corrections to those that have the affect of improving the analyst’s client’s position.

2.4. Identification and Quantification of Discrete Delay Events and Issues (SVP 2.4)

A. General Considerations

SVP 2.4 discusses the compilation of information regarding delay events, activities and influences that are
inserted or extracted in modeled methods or used in evaluating the observational methods. As stated in the introduction to the SVP, the approach of the SVP is to maximize the reliable use of the source data as opposed to assuring the reliability or the accuracy of the substantive content of the source data. The best accuracy that an analyst can hope to achieve is an objective reflection of the facts as represented in documents, data and witness statements. Whether that reflection is an accurate model of reality is almost always a matter of debatable opinion. This is especially true in assembling delay data and making the causal connection between the delay event or influence and the impacted activity.

1. ‘Delay’ Defined

For the purpose of this section, the term, ‘delay’, is considered neutral in terms of liability. Delay simply means a state of extended duration of an activity, or a state of an activity not having started or finished on time, relative to its predecessor.

a. Activity-Level Variance (ALV)

Forensic delay analysis primarily focuses on determining start or duration variances of a specific schedule activity otherwise known as activity-level variances or ALV’s.

ALV’s are the result of several types of delay causes:

- Waiting (delayed start)
- Performance (Productivity Impacts, Additional Work, etc.)
- Interruption (Work Stoppage, Weather, Strikes, etc.)

For example a delayed start of an activity awaiting a response to an RFI is the delay cause “waiting.” In contrast, a delayed start due to the performance of a scope of work that was missed at bid time is the performance of additional scope of work. Finally, an activity experiencing numerous rain days over several months is experiencing interruption of work or otherwise known as disruption. Given these variations there are two main ways in which ALVs are expressed in a CPM schedule:

i. Delayed Relative Start

This is the variance between the planned start relative to the planned controlling predecessor to the actual point of start. Because this is a relative measure, it cannot be determined by the comparison of planned date (either early or late) to the actual, which would yield a cumulative delay figure. The cumulative delay incorporates all the delays that occurred previously in the activity chain.

ii. Extended Duration

An extended duration delay occurs when the actual activity duration exceeds the planned original duration or reasonable duration required to perform the described activity. Unlike the delayed relative start case, extended duration calculations are not dependent on predecessor logic for quantification. Extended durations may result from continuous impact, intermittent impact such as stop-and-go operations, weather delays, or from discrete periods of added work or suspensions. In addition, extended durations may be due to experiencing lower labor productivity than planned for when the activity duration was developed. Unless the delay is fully attributable to a discretely identifiable period of exclusive extra work performance, quantification of this type of delay requires some estimating on the part of the analyst.
b. **Distinguishing ALV from Project-Level Variance (PLV)**

The ALV should be distinguished from the project-level variance (PLV) which is also a variance but at the overall project level. While the ALVs occur close in time to the causes, i.e. in the same period, the PLV may be months apart from the actual cause(s) of the delay PLV is the result of the aggregation of ALV’s after taking into account network float. Within the context of this RP, ALVs are considered ‘delays’ regardless of the amount of float they carry. The activity experiences a delay if an ALV exists regardless if the delay affects the project completion date, i.e. the PLV.

c. **Distinguishing Delay-Cause from Delay-Effect**

It is important for the analyst to be able to distinguish the cause of delay from the resulting effect. For example, a fully updated schedule may show extended activities and delayed start of activities relative to their controlling predecessors. While the cause may not be apparent, a competent status of the schedule will show the delay-effects. What caused the initial ALV for the chain of activities often does not appear on the schedule but must be investigated and researched using project documents, data and witness interviews. If, on the other hand, a delay was appropriately inserted into the schedule as a new activity as a predecessor to the activity with the start delay, the cause of the ALV is readily apparent.

The identification of delay-causes is a focus in the latter phases of delay analysis, during causation analysis.

d. **Delay Characterization is Independent of Responsibility**

ALV’s are considered “delays” independent of the responsibility for those variances. Thus an ALV can be contractor-caused or owner-caused, but it is still a delay. Similarly, the characterization of delays as ‘excusable’, ‘compensable’, ‘concurrent’ and ‘paced’ are attributes that are assigned well after the initial delay analysis starts by examining ALVs based on the causation analysis that has been performed after the schedule analysis is completed.

2. **Identifying and Collecting Delays**

a. **Two Main Approaches to Identification and Collection**

i. **Cause-Based Approach**

This approach starts with the collection of suspected causes of delays and then determining the effect they had on the baseline schedule and individual schedule updates. It is a ‘causes in search of effects’ approach. This is often used in the additive modeling methods. For example, an analysis may review the monthly reports, searching for issues that may have caused delays to the project.

ii. **Effect-Based Approach**

This approach is the opposite of the cause-based approach. It starts by compiling a set of ALV’s and then identifies the causes of those variances. Specific documents that are associated with the time-frame, activity description, and amount of ALV’s are reviewed to see if they could have created this variance. This approach is applied in the observational and the subtractive modeling methods. In the majority of the analysis scenarios, the effect-based approach is the more economical approach.
b. Criticality of the Delay

It is important for an analyst to not prejudge criticality, nor limit the collection process to only those delays perceived to affect the critical path, especially if the delays are being identified for a modeled method. In addition, a path that is near critical in one window may become critical in the next especially if delays are being extracted from the critical path. For example, in the Modeled / Subtractive / Single Simulation (MIP 3.8) and the Modeled / Subtractive / Multiple Base (MIP 3.9) methods, as delays are being stripped from the critical path, the path will “collapse” and the first near critical path will become critical. This is an iterative method and therefore, paths may collapse numerous times so that a path that originally has plenty of float becomes the critical path. The ultimate critical path quantification from the effect of each delay will eventually be determined in the modeling process. It is impossible for the analyst to know what the final critical path is until all of these delays have been added in (MIP’s 3.6 and 3.7 or extracted out (MIP’s 3.8 and 3.9).

Also, float consumption and ownership can be relevant where issues involve disruption, loss of productivity, and constructive acceleration regardless of the criticality of the activity.

3. Quantification of Delay Durations and Activity Level Variances

There are two different modes of quantification of delay durations. They are the retrospective actual mode (hindsight) and the prospective forecasted mode (blindsight). The hindsight mode relies on project documentation of actual chronological events that constitute the set of activities considered to be the cause or the effect of delays. The blindsight mode uses activities, sequences and durations that were estimated prior to the occurrence of the alleged delay. Where the focus of the analysis is to identify actual schedule impact, the hindsight mode is preferred. If the focus of the analysis is to identify potential impact or to ascertain the state of mind of the project team at the time of the impact, the analyst would use the blindsight mode.

Under either of these modes, there are two fundamentally different methods for quantifying delay durations. They are the variance method and the independent method.

a. Variance Method

The variance method is a comparative method that determines the delay duration by computing the ALV between the as-built activity duration and the unimpacted or planned activity duration obtained from the baseline schedule, an updated schedule or other non-CMP sources such as a measured-mile analysis or some reasoned estimate. This method is purely mathematical in nature. Two figures (a planned and an actual) are subtracted from each other to compute the variance. These two figures may be dates, durations, or productivity measurements. Thus, the entire variance needs to be tied to one or more causes for the variance.

b. Independent Method

In contrast, the independent method is not comparative. The delay duration is determined from project documentation that contemporaneously chronicled or otherwise recorded the occurrence of the delay or quantified the impact resulting from a delay event. Under this method, the answer to the question whether causation has been established or not depends on the type and content of the documentation that was used for the quantification.

These methods do not have to be exclusive of each other. The analyst may elect to use a mixture of the two methods depending on the nature of the delay or the availability of necessary documentation. Also,
one may elect to use both methods for each delay to evaluate and reconcile the different outcomes resulting from the differences.

For example, if the documentation consists of a daily diary entry that states that a specific activity was suspended for that specific day pending an investigation of a differing site condition, there is prima facie establishment of causation (one day of delay is clearly stated). But if the documentation is a letter stating that, “during the previous month many activities experienced extensive delays due to Owner-changes,” further analysis to determine the delay duration and which activities were affected by the delaying events will be needed.

The example below is given to illustrate the difference between the variance and independent method: Suppose that the ALV for a specific activity is ten days. In the variance method, the entire ten days will be distributed among the responsible parties. However, in the independent method, the ALV is not even looked at in the beginning. Instead, the analyst researches project documentation to determine the delay amount. Therefore, if the project documentation only states that the activity was delayed three days by an event, the remaining seven days of the ALV will not be assigned to this delay and may not be assigned to the party responsible for this delay. If the documentation states the delay event was twelve days, the analyst will consider the delay to the activity was twelve days but since the ALV is ten, the other two days may have been made up via acceleration. Therefore, in the variance method, the analyst is guided to the delay amount by the amount of ALV. On the other hand, in the independent method, the analyst does not review the ALV, but relies on what is written in the documentation to make its determination of delay amount.

4. Cause of Variance

What caused the variances often does not appear on the schedule but must be investigated and researched using project documents, data and witness interviews. In researching, evaluating and modeling the cause-and-effect relationships, the analyst must be aware that these relationships are often successively linked into a chain of alternating causes and effects. In addition, an ALV may be created by more than one cause.

Causation is established primarily on the quality of documents available for the analyst at the time of the schedule analysis. Some documents are more reliable than others.

Development of a document-type list and a reliability assessment for each document type are often the first steps prior to a detailed review of the record. This list is essential for two reasons. First, the analyst will become familiar with the types of documents that are available for review. Discussions with the project team concerning types of documents as well as the chronology of events will optimize the causation research process. For example, if the analyst is not aware that daily construction reports exist, and instead relies on monthly reports for determining causation, its conclusions of delay amount and impact may be very different.

5. Assigning or Assuming Variance Responsibility

When the forensic schedule analyst does not possess adequate information to make an independent determination of responsibility for the delay, the analyst may have to proceed with the analysis based on an assumption. Such assumptions should be noted and clearly stated as part of the final analysis product along with the basis of such assumption.

a. Contractor delay is any delay event caused by the contractor or those under its control, or the risk of which has been assigned solely to the contractor. Typical examples of contractor delay events
include, but are not limited to, delays caused by rework resulting from poor workmanship, subcontractor delays, insufficient labor, management and coordination problems, failure to order necessary materials and failure to secure contractual approvals.

b. **Owner delay** is any delay event caused by the owner, or the risk of which has been assigned solely to the owner. Examples of owner-delay events include, but are not limited to, delays resulting from change orders, extended submittal review, directed suspension of work, delayed owner-furnished equipment, differing site conditions, and defective contract documents.

c. **Force majeure delay** is any delay event caused by something or someone other than the owner (including its agents) or the contractor (or its agents), or the risk of which has not been assigned solely to the owner or the contractor by contract language and/or local industry custom and practice. Examples of force majeure delays include, but are not limited to, delays caused by acts of God, inclement weather, acts of war, extraordinary economic disruptions, strikes, and other events not foreseeable at the time of contract. Many contracts specifically define force majeure events. Although strictly not a ‘force majeure’ event, delays caused by parties external to the contract may also be classified under this category if there are no contractual risk assignment to the contractor or the owner for such delays.

**B. Recommended Protocol**

1. Determine the delay identification and collection approach to be used.

2. Tabulate all sources of delay data and evaluate each for reliability. If the documentation sources have conflicting data, the analyst should use the source that is the most reliable and explain why the source used is considered the most reliable.

3. Identify the specific actual start date and actual finish date for each delay along with the scope of work that occurred on those dates and their significance in relation to the delay.

4. Correlate the delay event to the specific activity or activities in the schedule affected by the delay and determine if it affected the start of the activity or the duration of the activity.

5. Identify, tabulate, and quantify all significant activity-level variances. The significance of the ALV is done on a case by case basis, but the criteria for that significance and their bases should be noted.

6. Determine the criticality of those significant ALVs.

7. Determine the causation of those significant ALVs based on the correlation of delay event to activity as described in step number four.

8. Determine responsibility or proceed based on assumed allocation of responsibility.

9. Quantify the claim portion of each ALV for which causation has been determined.

   a. If the delay is not a complete stoppage or not continuous throughout the entire period of the activity’s duration, quantify the net delay duration during that time frame.

   b. For each delay issue, if applicable, distinguish the informational delay portion from the actual performance of disputed/extra work.
c. For each discrete delay event, identify the activity ID number or numbers of the schedule activity or activities that were impacted by the delay.

C. Recommended Enhanced Protocol

1. Establish the activity coding structure for various attributes of delays, such as responsibility, issue grouping and documentation source so that different delay scenarios can be analyzed and relevant reports can be generated with minimal difficulty.

2. For each delay issue, if applicable, document and reconcile the claimed delay duration against any contract time extensions already received for that issue. The analyst needs to ensure that the entitlement quantification does not overlap or “double-dip” on pre-existing granted time extensions.

D. Special Procedures

1. **Duration and Lag Variance Analysis**

   Prepare a table comparing the planned duration of a schedule activity to the actual duration and determine the cause for each significant variance.

   Prepare a table comparing the planned controlling predecessor logic of the schedule activity to the actual controlling predecessor logic and determine the cause for each significant variance both in terms of change in type of logic and lag values.

3. **METHOD IMPLEMENTATION**

   The intent of the Method Implementation Protocols (MIP) is to describe each forensic schedule analysis method identified in the Taxonomy and to provide guidance in implementing these methods. The user is reminded that the focus of this RP is on procedure as opposed to substance. Adopting a method and using the recommended procedures do not, on their own, assure soundness of substantive content.

   The use of the Source Validation Protocols (SVP) discussed in Section 2 is integral to the implementation guidelines discussed here. Therefore a thorough understanding of the SVP is a prerequisite to the competent use of the MIP.

Method implementation protocols consist of the following:

3.1. Observational / Static / Gross (MIP 3.1)
3.2. Observational / Static / Periodic (MIP 3.2)
3.3. Observational / Dynamic / Contemporaneous As-Is (MIP 3.3)
3.4. Observational / Dynamic / Contemporaneous Split (MIP 3.4)
3.5. Observational / Dynamic / Modified or Recreated (MIP 3.5)
3.6. Modeled / Additive / Single Base (MIP 3.6)
3.7. Modeled / Additive / Multiple Base (MIP 3.7)
3.8. Modeled / Subtractive / Single Simulation (MIP 3.8)
3.9. Modeled / Subtractive / Multiple Base (MIP 3.9)
3.1. Observational / Static / Gross (MIP 3.1)

A. Description

MIP 3.1 is an observational technique that compares the baseline or other planned schedule to the as-built schedule or a schedule update that reflects progress.

![Diagram of Observational, Static, Gross Analysis Method]

Figure 3 – Observational, Static, Gross Analysis Method Graphic Example

In its simplest application, the method does not involve any explicit use of CPM logic and can simply be an observational study of start and finish dates of various activities. It can be performed using a simple graphic comparison of the as-planned schedule to the as-built schedule. A more sophisticated implementation compares the dates and the relative sequences of the activities and tabulates the differences in activity duration, and logic ties and seeks to determine the causes and explain the significance of each variance. In its most sophisticated application, it can identify on a daily basis the most delayed activities and candidates for the as-built critical path.

MIP 3.1 is classified as a static logic method because it primarily relies on the single set of CPM logic underlying the baseline or other planned schedule. The method is classified as gross as opposed to periodic because the analysis is performed on the entire project against a single baseline or other planned schedule rather than in periodic segments.

B. Common Names

1. As-planned vs. as-built
2. AP vs. AB
3. Planned vs. actual
4. As-planned vs. update
C. Recommended Source Validation Protocols

1. Implement SVP 2.1 (baseline validation) and,
2. Implement SVP 2.2 (as-built validation) or,
3. Implement SVP 2.3 (update validation) and,
4. Implement SVP 2.4 (delay ID & quantification)

D. Enhanced Source Validation Protocols

[Not used.]

E. Minimum Recommended Implementation Protocols

The application of this methodology involves the sequential comparison of individual activities’ planned start and finish dates with actual start and finish dates. Through this comparison, a detailed summary of the delays and/or accelerations of activities can be identified. Generally, it is best to compare the LATE planned dates from a CPM schedule, rather than the early dates. While contractors usually intend to perform their work in accordance with the early dates, delay to an activity cannot be measured until the activity is actually delayed— is later than the planned late dates. The basic steps in the analysis are as follows:

1. Identify the baseline or other schedule that will form the as-planned schedule. Ideally, this schedule has been approved or accepted by both parties and reflects the full scope of the work, includes proper logic from the start of the project through completion, and reflects neither progress nor post-commencement mitigations of delay. This schedule is usually a CPM model, so that even without functioning CPM logic and modeling, the original planned logic should be used in analysis and interpretation. Alternatively, a simple comparison can be performed using graphic time-scaled diagrams. In this situation, no explicit schedule logic is evident, although the sequence and timing will imply certain logical connections.

2. The comparison progresses from the earliest activities’ planned dates to later dates. Generally, this comparison sequence should follow the logic in the original as-planned schedule. Thus, at least until the first significant delays, the focus will be on the as-planned critical and near-critical paths.

3. The analysis should advance through the comparison by identifying for each activity: (a) delayed starts, (b) extended durations, and (c) delayed finishes. Since the as-built analysis is performed using a 7-day calendar, it is important that all durations be in calendar days. In this manner, it is possible to identify where the most significant delays occurred, where there were mitigations of delay through implementation of out-of-sequence logic and possible accelerations through shorter than planned durations.

4. Arithmetic calculations performed at the start and completion of each as-built activity provide a detailed view of the relative delay of every as-built activity. The most delayed series of activities can be ascertained using this method and can often be used as a starting point for identifying the as-built critical path. Expert judgment is required to separate the as-built critical path (based on industry experience and contemporaneous evidence as discussed in Subsection 4.3.C) from the various set of most delayed activities at any particular time.

5. Simultaneous delays, whether they are pacing delays (see Subsection 4.2.B) or concurrent delays (see Subsection 4.2.A), should be identified and confirmed as being on the critical path.
6. As the analysis continues and advances through the as-planned schedule, it is likely that it will become less accurate since contemporaneous adjustments to the contractor’s plan will supersede the original logic. For this reason, particular care must be exercised during the analysis of the later stages of the project.

7. Extended durations that extend the Late Finish Date for any activity should be examined for the cause. This will determine the cause of the delays along the critical path.

8. Similarly, any duration with shorter than planned durations may indicate reductions in work scope or acceleration by the contractor.

9. If time extensions have been granted, they should be considered both at the time they were granted and at the end of the analysis. Time extensions should be considered at the time granted when the reasons for delayed performance are identified through the comparison as well as identification of the as-built critical path. Time extensions will change the overall delay to the project and may therefore override apparent delays to specific activities.

If the baseline schedule has both early and late dates, the analysis should be performed using late dates unless a review of the late dates reveal that the logic associated with the late dates is significantly different than the logic of the early dates. In this situation, the analysis should be performed using early dates with the understanding that adjustments for available float may need to be considered. A schedule with logic that is incomplete or has logic associated with the late dates that appears significantly different from the logic associated with the early dates should be considered for correction in accordance with Subsection 2.1.B.

The minimum implementation of this method is applicable only to relatively simple cases and should not be used for long duration cases or where there are significant changes between the original planned work scope and the final as-built scope. For the purpose of this MIP, a ‘simple case’ is defined as one in which there is a single clearly defined chain of activities on the longest path that stayed as the longest path throughout the performance of the project.

F. Enhanced Implementation Protocols

1. Daily Delay Measure

The as-planned vs. as-built methodology can be used in more complicated cases if the data is available. Since the basic implementation protocol is applicable only for very simple cases, this more advanced method should be used if possible. However, even this more enhanced implementation is useful only for simple projects where the sequence of work did not vary significantly from the baseline schedule.

a. The as-built should be a fully progressed baseline schedule allowing for a one-to-one comparison of each schedule activity. This is essential as activity descriptions and ID numbers often change as the project advances.

b. On larger schedules and projects that are active for long periods of time, it is often desirable to use a database comparison between actual dates determined from the as-built analysis with the LATE planned dates. This comparison will allow the selection of the more significant activities for graphical comparison. Prepare a table comparing the planned duration or a schedule activity to the actual duration and determine the cause for each significant variance.

c. Prepare a table comparing the planned controlling predecessor logic of schedule activity to the actual controlling predecessor logic and determine the cause for each significant variance.
d. If an edited baseline schedule was used, the analysis should proceed using both the unaltered baseline as well as the modified baseline. A comparison between the two sets of results will assist the analysis in identifying the likely and realistic progress of the job.

e. Arithmetic calculations performed on a daily basis can provide significantly more accurate information if the as-built data is available at the appropriate level of detail. This method is called Daily Delay Measure (DDM). DDM is an enhanced variation for the identification of activities that are candidates for critical and near critical paths. DDM compares late start and finish dates with as-built start and finish dates.

- It can be done on a daily, weekly, or any other periodic basis. By depicting the number of days a schedule activity is ahead or behind the planned late dates, a determination of any point of the status of any schedule activity is possible.

- While the comparison can be made between the early start/finish dates and the actual dates, it is better to compare late start/finish dates with actual dates. By using late dates, any delay indicated by the comparison is a true delay rather than consumption of float. As a result of that exercise, any float associated with the duration of a schedule activity is excluded. Activities that have float (and accordingly are not on the as-planned critical path) will generally not appear to have been delayed during the early stages of analysis, since they will appear to be “ahead” of schedule because of their float. As the analysis progresses through a project’s performance, however, the activities that initially had float, if they were delayed for a duration in excess of the value of that float, can become critical, thus overtaking one or more of those activities originally on the project’s as-planned critical path. While late dates are preferred in performing the analysis, in some CPM schedules, late dates do not represent a consistent or practical plan for execution of the work even if the early dates do. In these cases, it is better to use early dates.

- The DDM can also identify possible changes in the as-built critical path if the analysis is done on a frequent, possible daily basis, even within the actual duration of activities. In this case there are several alternative assumptions that can be made to identify progress within an activity duration: (1) if accurate progress data is available on a regular basis, this regular progress can be used (realistically this is rare in most construction projects); (2) progress can be assumed to advance at an equal rate each period, for example, a 10-day activity would be assumed to advance 10 percent each day; or (3) a different progress rate, perhaps conforming to a more typical bell-curve distribution.

G. Identification of Critical and Near-Critical Paths

In this method, the emphasis should be on the as-built critical path as opposed to the baseline critical path. Since this methodology does not use a computational CPM, the methodology relies more extensively on expert evaluation.

- Identify and understand all related contractual language.

- From the fully populated baseline schedule, identify the calculated critical path of the baseline using the longest path and the lowest total float concept of the validated baseline.

- From the fully populated as-built schedule, identify the near-critical path using the procedure in Subsection 4.3.C. for identifying the as-built critical path.

- Confirm and cross check these results by tracing the delays through the as-planned critical path and
near critical paths based on late as-planned dates.

- Identify the most delayed activities at every measuring point.
- Review the planned logic and evaluate any likely changes based on contemporaneous evidence.

H. Identification and Quantification of Concurrent Delays and Pacing

- Identify and understand all related contractual language.
- Determine whether literal or functional concurrency theory is to be used (see Subsection 4.2).
- If applicable, determine the near-critical threshold (see Subsection 4.3.).
- If applicable, determine the frequency, duration, and placement of the analysis intervals.
- Determine whether there are two simultaneous delays to activities on the critical path, or two simultaneous causes of delay to a single activity on the as-built critical path.
- Determine the day each delay commenced or period within which each commenced.
- Determine the contractually responsible party for each delay by the contractor or owner at issue.
- For each delay event, distinguish the cause from the effect of delay.
- Identify and explain all relative delayed starts and extended duration of activities that are critical or near-critical.
- For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.
- For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings resulting from analyses performed under this RP.

Absent such overriding language, use the following procedure:

1. Excusable and Compensable Delay (ECD)

Each incremental delay along the as-built critical path should be independently quantified and the cause of the delay identified. The net Excusable & Compensable Delay (ECD) is the sum of the individual delays that: 1) were the responsibility of the owner, and 2) delayed the completion date of the project, and 3) were not concurrent with delays which were the responsibility of the contractor or force majeure events.

2. Excusable and Non-Compensable Delay (END)
Each incremental delay along the as-built critical path should be independently quantified and the cause of the delay identified. The net Excusable & Non-compensable Delay (END) is the sum of the individual owner-caused or relevant third-party caused delays that: 1) were force majeure events or were concurrent with contractor-responsible delays or force majeure events, and 2) delayed the completion date of the project, and 3) were not the responsibility of the contractor.

J. Identification and Quantification of Mitigation / Constructive Acceleration

Observational / static analysis methods can note differences in logic but cannot directly quantify net critical path impact. However, there may be evidence of reduced individual activity duration, which when coupled with detailed records of increased man-hours, would serve as adequate proof of acceleration. Note that the acceleration would be evident in both critical path and non-critical path activities.

K. Specific Implementation Procedures and Enhancements

[Not Used]

L. Summary of Considerations in Using the Minimum Protocol

- Suitable for analyzing short projects with minimal logic changes.
- Can be performed in a manner that is easy to understand and simple to present.
- Technically simple to perform compared to other MIP’s.
- Can be performed with very rudimentary schedules and as-built data.
- As-built activities must be closely correlated with as-planned activities.
- As-built data used must be accurate and validated.
- Does not, by itself, identify the as-built critical path.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

- Not suitable for project durations extending into multiple dozens of update periods.
- Not suitable for projects built in a manner significantly different than planned. The rate of error increases as the incidence of change increases.
- Not suitable for complicated projects with multiple critical paths.
- Does not consider the possibility of critical path shifts either within periods or across the project.
- Susceptible to unintentional or intentional manipulation by choice of as-built data that is incorporated into schedule.
- May fail to identify all critical delays or time extensions, and typically does not adequately consider concurrency and pacing issues.
- Does not consider that changes to original baseline schedule may have been the actual cause of delay
instead of the identified delay issues

- Typically fails to consider chronological order of delays or reconcile periodic planned critical path shifts with the as-built critical path
- Not suited for clearly demonstrating acceleration

### 3.2. Observational / Static / Periodic (MIP 3.2)

#### A. Description

Like MIP 3.1, 3.2 is an observational technique that compares the baseline or other planned schedule to the as-built schedule or a schedule update that reflects progress. But, this method analyzes the project in multiple segments rather than in one whole continuum. Because this is essentially an enhancement of MIP 3.1, as a practical matter, the implementation of MIP 3.2 requires that prerequisites for MIP 3.1 be implemented first.

![Figure 4 – Observational, Static, Periodic Method Graphic Example](image)

In its range of implementation from simple to sophisticated, it shares the characteristics of MIP 3.1. In its simplest application, the method does not involve any explicit use of CPM logic and can be simply an observational study of start and finish dates of various activities. It can be performed using a simple graphic comparison of the as-planned schedule to the as-built schedule. A more sophisticated implementation compares the dates and the relative sequences of the activities, tabulates the differences in activity duration and logic ties, seeks to determine the causes, and explains the significance of each variance. In its most sophisticated application, it can identify on a daily basis the most delayed activities and candidates for the as-built critical path.

The advantage of performing this analysis in two or more time periods is that the identification of delays or accelerations can be more precisely identified to particular events. Generally the more time periods, the more closely related the analysis is to the events that actually occurred. The fact that the analysis is segmented into periods does not significantly increase or decrease the technical accuracy of this method when compared to MIP 3.1 because the comparison remains between the as-built and baseline or original as-planned schedule. However, the segmentation is useful in enhancing the organization of the analysis process and enables prioritization. It also may add to the effectiveness of the presentation of the analysis.
MIP 3.2 is classified as a static logic method because it primarily relies on the single set of CPM logic underlying the baseline schedule or other planned schedule. Note that a similar method as described in MIP 3.3 is classified as a dynamic logic method because that method uses a series of updates schedule with logic that may be different from the baseline and from each other. MIP 3.2 is distinguished from MIP 3.3 in that while the analysis is performed in segments, they are segments of the as-planned and as-built without reference to schedule updates that are contemporaneous to those segments.

The method is classified as periodic because the analysis is performed in periodic segments rather than in one continuous project period.

B. Common Names

1. As-planned vs. as-built
2. AP vs. AB
3. Planned vs. actual
4. As-planned vs. update
5. Window analysis
6. Windows analysis

C. Recommended Source Validation Protocols

1. Implement SVP 2.1 (baseline validation) and,
2. Implement SVP 2.2 (as-built validation) or,
3. Implement SVP 2.3 (update validation) and,
4. Implement SVP 2.4 (delay ID & quantification)

D. Enhanced Source Validation Protocols

[Not used.]

E. Minimum Recommended Implementation Protocols

The procedures below are essentially those of MIP 3.1, but are applied only for a specific time period which is less than the overall duration of the project. Selection of the time periods should follow Subsection 3.2.A. In this method however, the selection is primarily made for clarity of conclusions, not for greater accuracy of analysis.

The results of this analysis are summed at the end of each time analysis period. The application of this methodology involves the sequential comparison of individual activities’ planned start and finish dates with actual start and finish dates. Through this comparison, a detailed summary of the delays and/or accelerations of activities can be identified. Generally, it is best to compare the LATE planned dates from a CPM schedule rather than the early dates. While contractors usually intend to perform their work in accordance with the early dates, delay to an activity cannot be measured until the activity is actually delayed—is later than the
planned late dates. The basic steps in the analysis are as follows:

1. Identify the baseline or other schedule that will form the as-planned schedule. Ideally, this schedule has been approved or accepted by both parties and reflects the full scope of the work, includes proper logic from the start of the project through completion, and reflects neither progress nor post-commencement mitigations of delay. This schedule is usually a CPM model, so that even without functioning CPM logic and modeling, the original planned logic should be used in analysis and interpretation. Alternatively, a simple comparison can be performed using graphic time-scaled diagrams. In this situation, no explicit schedule logic is evident, although the sequence and timing will imply certain logical connections.

2. The comparison progresses from the earliest activity planned dates to later dates. Generally, this comparison sequence should follow the logic in the original as-planned schedule. Thus, at least until the first significant delays, the focus will be on the as-planned critical and near-critical paths.

3. The analysis should advance through the comparison by identifying for each activity: (a) delayed starts, (b) extended durations, and (c) delayed finishes. Since the as-built analysis is performed using a 7-day calendar, it is important that all durations be in calendar days. In this manner, it is possible to identify where the most significant delays occurred, in which there were mitigations of delay through implementation of out-of-sequence logic, and possible accelerations through shorter than planned durations.

4. Arithmetic calculations performed at the start and completion of each as-built activity provide a detailed view of the relative delay of every as-built activity. The most delayed series of activities can be ascertained using this method and can often be used as a starting point for identifying the as-built critical path. Expert judgment is required to identify the as-built critical path, based on industry experience and contemporaneous evidence as discussed in Subsection 4.3.C, from the various set of the most delayed activities at any particular time.

5. Simultaneous delays, whether they are pacing delays (see Subsection 4.2.B), or concurrent delays (see Subsection 4.2.A), should be identified and confirmed as being on the critical path.

6. As the analysis continues and advances through the as-planned schedule, it is likely that it will become less accurate since contemporaneous adjustments to the contractor’s plan will supersede the original logic. For this reason, particular care must be exercised during the analysis of the later stages of the project.

7. Extended durations that extend the Late Finish Date for any activity should be examined for the cause. This will determine the cause of the delays along the critical path.

8. Similarly, any activities with shorter than planned durations may indicate reductions in work scope or acceleration by the contractor.

9. If time extensions have been granted, they should be considered both at the time they were granted and at the end of the analysis. Time extensions should be considered when evaluating the reasons for delayed performance identified through the comparison as well as identification of the as-built critical path. Time extensions will change the overall delay to the project and may therefore override apparent delays to specific activities.

10. Prepare a table that summarizes the variances quantified for each analysis period and reconcile the total to the result that would be obtained by a competent implementation of MIP3.1. This is intended to eliminate the possibility of skewing the result of the analysis through the use of variable periods.
If the baseline schedule has both early and late dates, the analysis should be performed using late dates unless a review of the late dates reveal that the logic associated with the late dates is significantly different than the logic of the early dates. In this situation, the analysis should be performed using early dates with the understanding that adjustments for available float may need to be considered. A schedule with logic that is incomplete or significantly different from the logic associated with the early dates should be considered for correction in accordance with Subsection 2.1.B.

The minimum implementation of this method is applicable only to relatively simple cases and should not be used for long duration cases or where there are significant changes between the original planned work scope and the final as-built scope. For the purpose of this MIP, a ‘simple case’ is defined as one in which there is a single clearly defined chain of activities on the longest path that stayed as the longest path throughout the performance of the project.

F. Enhanced Implementation Protocols

1. Daily Delay Measure

The as-planned vs. as-built methodology can be used in more complicated cases if the data is available. Since the basic implementation protocol is applicable only for very simple cases, this more advanced method should be used if possible. However, even this more enhanced implementation is useful only for simple projects where the sequence of work did not vary significantly from the baseline schedule.

a. The as-built should be a fully progressed baseline schedule allowing for a one-to-one comparison of each schedule activity. This is essential as activity descriptions and ID numbers often change as the project advances.

b. On larger schedules and projects that are active for long periods of time, it is often desirable to use a database comparison between actual dates determined from the as-built analysis with the LATE planned dates. This comparison will allow the selection of the more significant activities for graphical comparison. Prepare a table comparing the planned duration or a schedule activity to the actual duration and determine the cause for each significant variance.

c. Prepare a table comparing the planned controlling predecessor logic of schedule activity to the actual controlling predecessor logic and determine the cause for each significant variance.

d. If an edited baseline schedule was used, the analysis should proceed using both the unaltered baseline as well as the modified baseline. A comparison between the two sets of results will assist the analysis in identifying the likely and realistic progress of the job.

e. Arithmetic calculations performed on a daily basis can provide significantly more accurate information if the as-built data is available at the appropriate level of detail. This method is called Daily Delay Measure (DDM). DDM is an enhanced variation for the identification of activities that are candidates for critical and near critical paths. DDM compares late start and finish dates with as-built start and finish dates.

- It can be done on a daily, weekly, or any other periodic basis. By depicting the number of days a schedule activity is ahead or behind the planned late dates, a determination at any point of the status of any schedule activity is possible.

- While the comparison can be made between the early start/finish dates and the actual dates, it is better to compare late start/finish dates with actual dates. By using late dates, any delay indicated
by the comparison is a true delay rather than consumption of float. As a result of that exercise, any float associated with the duration of a schedule activity is excluded. Activities that have float (and accordingly are not on the as-planned critical path) will generally not appear to have been delayed during the early stages of analysis, since they will appear to be “ahead” of schedule because of their float. As the analysis progresses through a project’s performance however, the activities that initially had float, if they were delayed for duration in excess of the value of that float, can become critical, thus overtaking one or more of those activities originally on the project’s as-planned critical path. While late dates are preferred in performing the analysis, in some CPM schedules, late dates do not represent a consistent or practical plan for execution of the work even if the early dates do. In these cases, it is better to use early dates, taking into account the float values.

- The DDM can also identify possible changes in the as-built critical path if the analysis is done on a frequent, possibly daily basis, even within the actual duration of activities. In this case, there are several alternative assumptions that can be made to identify progress within an activity duration: (1) if accurate progress data is available on a regular basis, this regular progress can be used (realistically this is very rare in most construction projects); (2) progress can be assumed to advance at an equal rate each period, for example a 10-day activity would be assumed to advance 10 percent each day; or (3) a different progress rate, perhaps conforming to a more typical bell-curve distribution.

G. Identification of Critical and Near-Critical Paths

In this method, the emphasis should be on the as-built critical path as opposed to the as-planned critical path. Since this methodology does not use a computational CPM, the methodology relies more extensively on expert evaluation.

- Identify and understand all related contractual language.
- From the fully populated baseline schedule, identify the calculated critical path of the as-planned using the longest path and the lowest total float concept of the validated as-planned schedule.
- From the fully populated as-built schedule, identify the near-critical path using the procedure in Subsection 4.3.C. for identifying the as-built critical path.
- Confirm and cross check these results by tracing the delays through the as-planned critical path and near critical paths based on late as-planned dates.
- Identify the most delayed activities at every measuring point.
- Review the planned logic and evaluate any likely changes based on contemporaneous evidence.

H. Identification and Quantification of Concurrent Delays and Pacing

- Identify and understand all related contractual language.
- Determine whether literal or functional concurrency theory is to be used.
- If applicable, determine the near-critical threshold (see Subsection 4.3.).
- If applicable, determine the frequency, duration, and placement of the analysis intervals.
• Determine whether there are two simultaneous delays to activities on the critical path or two simultaneous causes of delay to a single activity on the as-built critical path.

• Determine the day each delay commenced or period within which each commenced.

• Determine the contractually responsible party for each delay by the contractor or owner at issue.

• For each delay event, distinguish the cause from the effect of delay.

• Identify and explain all relative delayed starts and extended duration of activities that are critical or near-critical.

• For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.

• For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings resulting from analyses performed under this RP.

Absent such overriding language, use the following procedure.

1. Excusable and Compensable Delay (ECD)

Each incremental delay along the as-built critical path should be independently quantified and the cause of the delay identified. The net Excusable & Compensable Delay (ECD) is the sum of the individual delays that: 1) were the responsibility of the owner, and 2) delayed the completion date of the project, and 3) were not concurrent with delays which were the responsibility of the contractor or force majeure events.

2. Excusable and Non-Compensable Delay (END)

Each incremental delay along the as-built critical path should be independently quantified and the cause of the delay identified. The net Excusable & Non-compensable Delay (END) is the sum of the individual owner-caused delays that: 1) were force majeure events or were concurrent with contractor-responsible delays or force majeure events, and 2) delayed the completion date of the project, and 3) were not the responsibility of the contractor.

J. Identification and Quantification of Mitigation / Constructive Acceleration

Observational / Static analysis methods can note differences in logic but cannot directly quantify net critical path impact. However, there may be evidence of reduced individual activity duration, which when coupled with detailed records of increased man-hours, would serve as adequate proof of acceleration. Note that the acceleration would be evident in both critical path and non-critical path activities.

K. Specific Implementation Procedures and Enhancements

1. Fixed Periods
The analysis periods are of virtually identical duration and may coincide with regular schedule update periods.

2. Variable Periods

The analysis periods are of varying durations and are characterized by their different natures such as the type of work being performed, the types of delaying influences, significant events, changes to the critical path, revised baseline schedules, and/or the operative contractual schedule under which the work was being performed.

Fixed periods have the advantage of providing regular measurements and thus make it easier to track progress through the project. However, variable periods identified by major events on the project are often more useful since they will relate status of the delay to a specific known event.

L. Summary of Considerations in Using the Minimum Protocol

- Allows for logical segmenting of relatively longer project durations than MIP 3.1
- Suitable for analyzing short projects with minimal logic changes.
- Can be performed in a manner that is easy to understand and simple to present.
- Technically simple to perform compared to other MIP’s, other than MIP 3.1. However it is still relatively time consuming when implemented correctly.
- Can be performed with very rudimentary schedules and as-built data.
- As-built activities must be closely correlated with as-planned activities.
- As-built data used must be accurate and validated.
- Does not, by itself, identify the as-built critical path.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

- Provides illusion of greater detail and accuracy compared to MIP 3.1 where none exists since it still does not consider the possibility of critical path shifts either within periods or across the project.
- Does not use the contemporaneous as-planned update predictions of critical paths
- The choice of variable periods may be abused to skew the results of the analysis.
- Not suitable for project durations extending into multiple dozens of update periods.
- Not suitable for projects built in a manner significantly different than planned. The rate of error increases as the incidence of change increases.
- Not suitable for complicated projects with multiple critical paths.
- Susceptible to unintentional or intentional manipulation by choice of as-built data that is incorporated into schedule.
• May fail to identify all critical delays or time extensions, and typically does not adequately consider concurrency and pacing issues.

• Does not consider that changes to original baseline schedule may have been the actual cause of delay instead of the identified delay issues.

• Typically fails to consider chronological order of delays.

• Typically fails to reconcile periodic planned critical path shifts with the as-built critical path.

• Not suited for clearly demonstrating acceleration due to reliance on original as-planned logic only.

3.3. Observational / Dynamic / Contemporaneous As-Is (MIP 3.3)

A. Description

MIP 3.3 is a retrospective technique that uses the project schedule updates to quantify the loss or gain of time along a logic path that was or became critical and identify the activities responsible for the critical delay or gain. Although this method is a retrospective technique, it relies on the forward-looking calculations made at the time the updates were prepared. That is, it primarily uses the information to the right of the updates’ data dates.

MIP 3.3 is an observational technique since it does not involve the insertion or deletion of delays but instead is based on observing the behavior of the network from update to update and measuring schedule variances based on essentially unaltered, existing schedule logic.

Because the method uses schedule updates whose logic may have changed from the previous updates as well as from the baseline, it is considered a dynamic logic method.

It is labeled contemporaneous because the updates it relies on were prepared contemporaneously with the project execution as opposed to reconstructed after-the-fact as in MIP 3.5.

Finally, the ‘as-is’ label distinguishes this method from MIP 3.4 by the fact that the updates are evaluated almost completely untouched or ‘as is’.

While rare, it is possible that no non-progress revisions were made in the contemporaneous updates. In this situation, this method should yield a result similar to a static logic method (MIP 3.1 and 3.2) since the initial baseline logic is in place for the entire project.

B. Common Names

1. Contemporaneous period analysis

2. Contemporaneous project analysis

3. Observational CPA

4. Update analysis

5. Month-to-month
6. Window analysis

7. Windows analysis

C. Recommended Source Validation Protocols

1. Implement SVP 2.1 (baseline validation) and,

2. Implement SVP 2.3 (update validation)

D. Enhanced Source Validation Protocols

1. Implement SVP 2.2 (as-built validation)

2. Implement SVP 2.4 (identification of delay events)

E. Minimum Recommended Implementation Protocols

1. Recognize all contract time extensions granted.

2. Identify the critical path activity that will be used to track the loss or gain of time for the overall network.

3. Determine whether evaluations will be done on all periods or grouped periods as described in Subsection 3.3.K.

4. Every update may not be used. However, every update should be considered. Accuracy is reduced if updates are not evaluated for multiple-month periods when schedule revisions or changes in sequence occurred to the project plan.

5. Separately identify activities that will be used to track intra-network time losses and gains, such as interim milestones.

6. Compare the update at the start of the analysis period to the update at the end of the analysis period.

7. Use the longest path and the least float criteria to identify the controlling chain of activities.

8. Identify changes (gained or lost time) in overall Project completion date based on the critical path activity identified in 3.3.E.2, and if necessary, in interim milestone completion dates.

9. Identify start and finish variances of critical and near-critical activities in the analysis period.

10. Indentify all changes and/or revisions to logic, durations, and/or progress that were made during analysis period.

11. Identify responsibility for delays and gains during analysis period.

12. Continue with implementation until all periods are complete.

13. Sum the net gains and losses for each period to arrive at an overall impact to the project. The sum of the net impacts must be equal to difference between the first schedule update and last schedule update used in the evaluation.
F. Enhanced Implementation Protocols

1. Use every contemporaneous update

2. If minor logic revisions are made or schedule anomalies are corrected prepare alternate evaluations using updates without the corrections and compare the results.

3. Daily Progress Method

The application of this methodology involves identifying the delay or savings in time attributable to the project’s progress between the updates by chronologically tracking progress along the critical path on a unit basis (typically the smallest planning unit used in executing the project, for example, daily), by comparing the planned timing of the activities in the first update to their actual progress as depicted in the second, and identifying the resulting effect of the project’s progress. The following steps outline the application of this methodology:

a. Identify the consecutive schedules that will be used to measure the delay or savings in time. For example, update No. 1 and update No. 2.

b. Using a copy of the first update, insert the progress made on day 1 of the update period, as depicted in the second update, and re-status the progressed update with a data date of the next calendar day.

c. Compare the critical paths of the first update and the progressed update to identify the activity(ies) whose progress or lack of progress affected the project’s milestones.

d. Separately measure the effect of the responsible critical activity(ies) to the project milestones. In doing so, the analyst should separately identify critical activity(ies) that cause delay and other critical activities that may show out-of-sequence progress resulting in a savings in time to the project milestones.

e. Repeat this procedure of inserting the project’s progress on a daily basis for every calendar day between the updates, while identifying and measuring the effect of progress on the critical paths of consecutive calendar days until reaching the data date of the second update.

f. This step concludes with the creation of a totally-progressed version of the first update, with the second update’s data date, that contains all of the progress contained in the second update and that depicts the status of the project before the development of the second update.

The distribution of progress to activities that made progress between the updates can determine whether an activity becomes critical and potentially delays the project. For example, assume an activity started before the update period, made five workdays of progress during the update period, and was not completed during the update period. If there are no contemporaneous documents to identify when those five workdays of progress occurred, then the analyst has to decide when and how to depict the work occurring between the updates. The analyst could assume that the progress occurred within the first available five workdays of the period, or the last available workdays of the period, or in some other manner between the updates. Regardless of which method is chosen to distribute progress between the updates, the analyst should consistently apply the chosen method throughout the entire analysis and be able to explain why the method was chosen.

Upon completion of these steps, the analyst will be able to specifically identify the activities that were responsible for the delay or savings in time to the project’s milestones during the update period and
assign the resultant delay or savings to those same activities caused by the progress made between the updates. Additionally, by tracking the progress along the critical path between the updates the analyst will be able to identify shifts in the critical path.

This process is performed between all consecutive updates throughout the entire project duration.

G. Identification of Critical and Near-Critical Paths

- Identify and understand all related contractual language.
- Identify the negative float theory being used by the opposing analyst.
- For each analysis interval, identify the calculated critical path using the longest path and the lowest total float concept of the validated update(s) corresponding to the analysis interval.
- The near-critical activity-set in each analysis interval is the one that yields the most number of activities using one of the following methods:
  - lowest float value in the update PLUS the average duration of all discrete delay events contained in whole or in part inside the analysis interval, or
  - lowest float value in the update PLUS duration of the analysis interval.

H. Identification and Quantification of Concurrent Delays and Pacing

- Determine whether compensable delay by contractor or owner is at issue.
- Identify and understand all related contractual language.
- For each delay event, distinguish the cause from the effect of delay.
- Determine whether literal or functional concurrency theory is to be used.
- If applicable, determine the near-critical threshold (see Subsection 4.3.).
- If applicable, determine the frequency, duration, and placement of the analysis intervals.
- For each analysis interval, identify the critical path(s) and the near-critical path(s) and explain all relative delayed starts and extended duration of activities that occurred in the previous analysis interval on the same chains of activities.
- For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.
- For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings
resulting from analyses performed under this RP.

Absent contract language or other agreements, use the following procedure to determine the net total delay apportionment:

1. **Non-Excusable and Non-Compensable Delay (NND)**
   a. For each period analyzed, determine the longest-path delay attributable to events that are contractor-caused that occurred between the current data date and the last data date.
   b. For each period analyzed, determine the longest-path gains attributable to contractor-initiated schedule mitigation that was actually implemented, and then add the resulting values together.
   c. Make adjustment for concurrent delays due to owner-caused and *force majeure*-caused events using the selected concurrency analysis method.

2. **Excusable and Compensable Delay (ECD)**
   a. For each period analyzed, determine the longest-path delay attributable to events that are owner-caused that occurred between the current data date and the last data date.
   b. For each period analyzed, determine the longest-path gains attributable to owner-initiated schedule mitigation that was actually implemented, and then add the resulting values together.
   c. Make adjustment for concurrent delays due to contractor-caused and *force majeure*-caused events using the selected concurrency analysis method.

3. **Excusable and Non-Compensable Delay (END)**
   a. Total network delay less total NND less total ECD is the total END.

**J. Identification and Quantification of Mitigation / Constructive Acceleration**

The observational / dynamic analysis methods are especially well-suited for identifying and quantifying acceleration and delay mitigation through the use of logic changes. These methods allow the analyst to not only quantify the acceleration, but also determine whether the acceleration was achieved by current, actually implemented measures, or by logic changes representing promise of future acceleration.

With MIP 3.3, acceleration or delay mitigation is identified by comparing the completion date of the longest path of the previous period with that of the current period. A current date that is earlier than the previous date suggests acceleration. However, note that the value is a net number potentially representing both slippage and gain, where the gain was greater than the slippage. Thus a detailed examination of the longest path and the near-longest path surrounding the data date is necessary along with the examination of the logic changes between the last and the current periods along those paths is necessary for a competent identification and quantification of acceleration and delay mitigation.

In order to determine whether the promised future acceleration was actually implemented, it will be necessary to compare the proposed accelerated fragnet with an as-built of the same activities. The process can become complicated if the actual execution of the accelerated scenario was hampered by delays that occurred subsequent to the formulation of the acceleration scenario.
K. Specific Implementation Procedures and Enhancements

1. All Periods

The analysis is performed for each and all contemporaneous updates. Whether the periods are of fixed or variable width is dictated by the frequency of the contemporaneous updates, not by the forensic analyst.

The all-periods implementation yields more information than the grouped-periods implementation and is considered more complete in that it identifies and measures the critical project delay for the entire project duration. Also the grouped-periods implementation allows the analyst to ignore periods that may be unfavorable to the party for which the analysis is being performed by not explicitly showing the variances between the updates within each grouping.

2. Grouped Periods

The analysis is performed for grouped periods where each group may contain updates between two or more updates with the same planned critical path being compared for variance calculation. So for example, a group may be the period starting with the January update and ending with the May update, and contain three other updates (February, March, April). The three updates are not ignored but may not be directly utilized in quantifying the variance. The analyst should ensure that changes in the logic sequence within the grouped periods are taken into consideration in the grouped period analysis in order to avoid missing significant shifts in the critical path that could affect causal activities for delay or gain.

3. Blocked Periods

The individual periods, whether prepared in the all-periods mode or the grouped-periods mode, can be gathered into blocks for summarization. Blocking is mentioned here to distinguish the practice from grouping. Blocking is the summing of the variances obtained in several contiguous periods of an all-periods implementation, while grouping skips over the individual variance calculation for periods inside the group.

4. Changing the Contemporaneous Project Schedule During the Analysis

MIP 3.3 is an observational technique that does not involve the insertion or deletion of delays, but instead is based on observing the behavior of the network from update to update and measuring schedule variances based on unaltered, existing logic models. The analyst’s preference is to identify and measure the critical project delays using the contemporaneous project schedules as they existed during the project.

However minor corrections to the contemporaneous schedules do not automatically result in a shift in classification of the analytical technique from MIP 3.3 to MIP 3.5 (Observational / Dynamic / Modified or Recreated). Certain limited corrections do not rise to the level of “recreations” or “modifications” and, thus, a MIP 3.3 analysis conducted using schedules with limited corrections is still properly characterized as a MIP 3.3 analysis and not a MIP 3.5 analysis. Refer to Subsection 2.3.D.3 for specific changes that can be implemented under this restriction.

The preference of every analyst should be to use the contemporaneous schedules and updates as they were prepared, reviewed, approved or accepted, and used on the project. This belief is grounded in the fact that the parties used the imperfect schedules to make decisions and manage the project work. Thus, these schedules, even though not perfect, are the best representation of the parties’ objectives and understanding of the project contemporaneously and are an indicator of each party’s performance.
However, absent contract language mandating the use of the contemporaneous schedules to quantify delay, MIP 3.3 is not so rigid that corrections to the contemporaneous schedules cannot be considered by the analyst.

All corrections should be described in the analyst’s report so that the other parties and the fact finders understand the changes that the analyst made to the contemporaneous schedule.

The issue of correcting the schedule is one of balance and reasonableness and, for this reason corrections should not be made across the board or automatically. Whenever the analyst believes that changes or modifications to the contemporaneous project schedule are necessary during the analysis, it must be kept in mind that MIP 3.3, is a “self-correcting” analysis.

Finally, the analyst must also be consistent and maintain independence and objectivity. The analyst cannot limit corrections to those that have the affect of improving the analyst’s client’s position.

One option is to run the analysis two ways. The first run of the analysis would use the schedules as they existed contemporaneously, or unaltered. The second run of the analysis would use the schedule with the minor correction. This approach allows the finder of fact to see the difference, understand the proposed minor modification, and make a reasoned decision without having to guess what the difference would have been between the performing the analysis with the unaltered schedule and with the corrected schedule.

L. Summary of Considerations in Using the Minimum Protocol

- Cannot be implemented if contemporaneous schedule updates do not exist.
- Uses as the primary tool a set of contemporaneous schedules that are already familiar to the parties at dispute.
- Can enhance credibility if it can be shown that the project participants used the contemporaneous schedules in managing and constructing the project.
- Accounts for the dynamics of evolving events and conditions because it considers the real-time perspective of project conditions, the state of mind, and knowledge of the project participants during each update period.
- Considers the dynamic nature of the critical path because it identifies shifts in the critical path between the updates.
- Delays or savings in time can be assigned to specific activities.
- Data preparation process may be quicker than other methods that require a separate as-built schedule.
- This method can be used to identify and specifically quantify acceleration.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

- The analyst may determine that the critical path responsible for project delays and gains, in hindsight, may be different from that indicated as the planned critical path shown in the contemporaneous schedule updates. Contemporaneous documentation should be provided with the analysis to support any instance of this determination.
To yield accurate results, the contemporaneous schedule updates used in the analysis must be validated as accurate both in reported progress and in the network’s representation of contemporaneous means and methods.

Except with very simple network models, it may be difficult to distinguish schedule variances caused by non-progress revisions from schedule variances caused purely by insufficient progress. Consider MIP 3.4 to overcome this challenge.

If date constraints were liberally used in the update schedules, analysis may be very difficult.

3.4. Observational / Dynamic / Contemporaneous Split (MIP 3.4)

A. Description

MIP 3.4 is identical to MIP 3.3 in all respects except that for each update an intermediate file is created between the current update and the previous update consisting of progress information without any non-progress revisions. Generally, the process involves updating the previous update with progress data from the current update and recalculating the previous update using the current data date. This is the intermediate schedule or the half-step schedule. The process allows the analyst to bifurcate the update-to-update schedule variances based on pure progress by evaluating the difference between the previous update and the half-step, and then the variance based on non-progress revisions by observing the difference between the half-step and the current update.

As with MIP 3.3, 3.4 is a retrospective technique that uses the project schedule updates to quantify the loss or gain of time along a logic path that was or became critical and identify the activities responsible for the critical delay or gain. Although this method is a retrospective technique, it relies on the forward-looking calculations made at the time the updates were prepared. That is, it primarily uses the information to the right of the updates’ data date.

MIP 3.4 is an observational technique since it does not involve the insertion or deletion of delays, but instead is based on observing the behavior of the network from update to update and measuring schedule variances based on essentially unaltered, existing schedule logic.

Because the method uses schedule updates whose logic may have changed from the previous updates as well as from the baseline, it is considered a dynamic logic method.

It is labeled contemporaneous because the updates it relies on were prepared contemporaneously with the project execution as opposed to reconstructed after the fact as in MIP 3.5.

The ‘split’ label distinguishes this method from MIP 3.3 by the fact that the updates are evaluated after the bifurcation process that splits the pure progress update from the non-progress revisions.

While rare, it is possible that no non-progress revisions were made in the contemporaneous updates. If that is the case, then MIP 3.3 is a better solution for the analysis.

B. Common Names

1. Contemporaneous period analysis
2. Contemporaneous project analysis
3. Contemporaneous schedule analysis

4. Bifurcated CPA

5. Half-stepped update analysis

6. Two-stepped update analysis

7. Month-to-month

8. Window analysis

9. Windows analysis

C. Recommended Source Validation Protocols

1. Implement SVP 2.1 (baseline validation)

2. Implement SVP 2.3 (update validation)

3. Implement SVP 2.2 D.2 (as-built validation)

D. Enhanced Source Validation Protocols

1. Implement SVP 2.2 (as-built validation)

2. Implement SVP 2.4 (identification of delay events)

E. Minimum Recommended Implementation Protocols

1. Recognize all contract time extensions granted.

2. Identify the critical path activity that will be used to track the loss or gain of time for the overall network.

3. Determine whether evaluations will be done on all periods or grouped periods as described in Subsection 3.4.K.

4. Every update may not be used. However, every update should be considered. Accuracy is reduced if updates are not evaluated for multiple-month periods when schedule revisions or changes in sequence occurred to the project plan.

5. Separately identify activities that will be used to track intra-network time losses and gains, such as on interim milestones.

6. Create a copy of the as-planned schedule and each of the update schedules for use in analysis as the bifurcated updates.

7. Import progress from the next update into each of the newly created bifurcated updates for use in identifying progress only gains and losses.

8. Compare the update at the start of the analysis period to the progress-only bifurcated update, and then
compare that progress-only bifurcated update to the update at the end of the analysis period.

9. Use both the longest path and the least float criteria to identify the controlling chain of activities.

10. Identify changes (gained or lost time) in overall Project completion date based on the critical path activity identified in 3.4.E.2, and if necessary, in interim milestone completion dates.

11. Identify start and finish variances of critical and near-critical activities in the analysis period.

12. Identify all changes and/or revisions to logic, durations, and/or progress that were made during analysis period.

13. Sum the net gains and losses for the update at the start of the update period and the bifurcated update for that same period. The net gains and losses must equal the net gains and losses between the start of the update period and the start of the next update period.


15. Continue with implementation until all periods are complete

16. Sum the net gains and losses for each period to arrive at an overall impact to the project. The sum of the net impacts must be equal to difference between the first schedule update and last schedule update used in the evaluation.

F. Enhanced Implementation Protocols

1. Use every contemporaneous update

2. If minor logic revisions are made or schedule anomalies are corrected prepare alternate evaluations using updates without the corrections and compare the results.

3. Daily Progress Method (see Subsection 3.3.F.1)

G. Identification of Critical and Near-Critical Paths

- Identify and understand all related contractual language.

- Identify the negative float theory being used by the opposing analyst.

- For each analysis interval, identify the calculated critical path using the longest path and the lowest total float concept of the validated update(s) corresponding to the analysis interval.

- The near-critical activity-set in each analysis interval is the one that yields the most number of activities using one of the following methods:
  - lowest float value in the update PLUS the average duration of all discrete delay events contained in whole or in part inside the analysis interval, or
  - lowest float value in the update PLUS duration of the analysis interval.

H. Identification and Quantification of Concurrent Delays and Pacing
• Determine whether compensable delay by contractor or owner is at issue.

• Identify and understand all related contractual language.

• For each delay event, distinguish the cause from the effect of delay.

• Determine whether literal or functional concurrency theory is to be used.

• If applicable, determine the near-critical threshold (see Subsection 4.3.)

• If applicable, determine the frequency, duration, and placement of the analysis intervals.

• For each analysis interval, identify the critical path(s) and the near-critical path(s) and explain all relative delayed starts and extended duration of activities that occurred in the previous analysis interval on the same chains of activities.

• For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.

• For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

(See Subsection 3.3.1)

J. Identification and Quantification of Mitigation / Constructive Acceleration

The observational / dynamic analysis methods are especially well-suited for identifying and quantifying acceleration and delay mitigation through the use of logic changes. These methods allow the analyst to not only quantify the acceleration, but also determine whether the acceleration was achieved by current, actually implemented measures, or by logic changes representing the promise of future acceleration.

The difference between this method and MIP 3.3 is that the bifurcation of each update into half-steps in MIP 3.4 makes it much easier to identify acceleration and delay mitigation that results from logic changes.

As with MIP 3.3, in 3.4, acceleration or delay mitigation is identified by comparing the completion date of the longest path of the previous period with that of the current period. A current date that is earlier than the previous date suggests acceleration. However, note that the value is a net number potentially representing both slippage and gain, where the gain was greater than the slippage. Thus, a detailed examination of the longest path, the near-longest path surrounding the data date, and the examination of the logic changes between the last and the current periods along those paths are necessary for a competent identification and quantification of acceleration and delay mitigation.

In order to determine whether the promised future acceleration was actually implemented, it will be necessary to compare the proposed accelerated fragment with an as-built of the same activities. The process can become complicated if the actual execution of the accelerated scenario was hampered by delays that occurred subsequent to the formulation of the acceleration scenario.

K. Specific Implementation Procedures and Enhancements
1. **All Periods**

The analysis is performed for each and all contemporaneous updates. Whether the periods are of fixed or variable width is dictated by the frequency of the contemporaneous updates, not by the forensic analyst.

The all-periods implementation yields more information than the grouped-periods implementation and is considered more complete in that it identifies and measures the critical project delay for the entire project duration. Also, the grouped-periods implementation allows the analyst to ignore periods that may be unfavorable to the party for which the analysis is being performed by not explicitly showing the variances between the updates within each grouping.

2. **Grouped Periods**

The analysis is performed for grouped periods where each group may contain updates between the two updates being compared for variance calculation. So, for example, a group may be the period starting with the January update and ending with the May update, and contain three other updates (February, March, April). The three updates are analyzed just as they would be analyzed if they were not grouped and the results would be the same, whether grouped or not. The analyst should ensure that changes in the logic sequence within the grouped periods are taken into consideration in the grouped period analysis in order to avoid missing significant shifts in the critical path that could affect causal activities for delay or gain.

3. **Blocked Periods**

The individual periods, whether prepared in the all-periods mode or the grouped-periods mode, can be gathered into blocks for summarization. Blocking is mentioned here to distinguish the practice from grouping.

4. **Bifurcation: Creating a Progress-Only Half-Step Update**

Bifurcation (a.k.a. half-stepping or two-stepping) is a procedure to segregate progress reporting from various non-progress revisions inherent in the updating process. Elements that are considered to be non-progress revisions include:

- Addition or deletion of activities
- Split or combined activities, using new activity IDs
- Addition or deletion of logic links
- Changes to lag value of logic links
- Addition, deletion, or changes to constraints
- Changes to OD
- Increase in RD such that RD becomes greater than OD
- Changes to RD not accompanied by changes to PCT
- Increase in RD of activities that have not started
Changes to calendar assignments
Changes to holiday assignments within a pre-existing calendar

The following is one of several step-by-step procedures used to perform the bifurcation:

a. Make a copy of the baseline or an updated schedule for which a half-step is to be created. The original baseline or update will be referred to herein as 01 and the copy as H1.

b. Update the copy, H1, using the progress data from the next schedule update [referred to herein as 02] for the following fields:

i. Actual start

ii. Actual finish

iii. Increased percent complete

iv. Decreased remaining duration

c. Recalculate schedule H1 by setting the data date\(^6\) to that used by 02.

d. The variance between the completion dates of H1 compared to that of 01 represents the slippage or gain due to progress during the update period.

e. The variance between the completion dates of H1 compared to that of 02 represents the slippage or gain due to non-progress revisions made in 02.

f. These two variance values add up to the variance between 01 and 02.

g. The validity of the H1 file should be checked by comparing the duration of the update period (that is, the difference between the two data dates) to the progress variance. If the progress variance value is greater than the duration of the update period, there are two possible explanations:

i. The first one is that there is a ‘pseudo-non-progress revision’ such as an increase in RD-value found itself in the H1 file. This needs to be fixed.

ii. The second possibility is that the lack of progress during the update period pushed subsequent activities into a period of no-work defined by the calendar. This does not need to be fixed.

h. Elements that are considered to be nuisances or complications that require case-by-case intervention by the analyst include:

i. Significant changes in activity descriptions to a schedule activity occupying a preexisting activity ID

ii. Assignments of a different activity ID to a preexisting schedule activity

iii. Changes in actual start or actual finish values previously reported

\(^6\) Note that in some software packages, for example, Microsoft Project, the default setting need to be changed to recognize the concept of the data date.
iv. Any change in calculation mode such as progress override and retained logic

Reversal of previously reported progress (i.e. deprogressing) by either increasing the value of remaining duration of the activity over the previously stated value or decreasing the percentage-complete value under what was previously reported.

5. Changing the Contemporaneous Project Schedule During the Analysis

MIP 3.4 is an observational technique that does not involve the insertion or deletion of delays, but instead is based on observing the behavior of the network from update to update and measuring schedule variances based on unaltered, existing logic models. The analyst’s preference is to identify and measure the critical project delays using the contemporaneous project schedules as they existed during the project.

However minor corrections to the contemporaneous schedules do not automatically result in a shift in classification of the analytical technique from MIP 3.4 to MIP 3.5 (Observational / Dynamic / Modified or Recreated). Certain limited corrections do not rise to the level of “recreations” or “modifications” and, thus, a MIP 3.4 analysis conducted using schedules with limited corrections is still properly characterized as a MIP 3.4 analysis and not a MIP 3.5 analysis. Refer to Subsection 2.3.D.3 for specific changes that can be implemented under this restriction.

The preference of every analyst should be to use the contemporaneous schedules and updates as they were prepared, reviewed, approved or accepted, and used on the project. This belief is grounded in the fact that the parties used the imperfect schedules to make decisions and manage the project work. Thus, these schedules, even though not perfect, are the best representation of the parties’ objectives and understanding of the project contemporaneously and are an indicator of each party’s performance. However, absent contract language mandating the use of the contemporaneous schedules to quantify delay, MIP 3.4 is not so rigid that corrections to the contemporaneous schedules cannot be considered by the analyst.

All corrections should be described in the analyst’s report so that the other parties and the fact finders understand the changes that the analyst made to the contemporaneous schedule.

The issue of correcting the schedule is one of balance and reasonableness and, for this reason corrections should not be made across the board or automatically. Whenever the analyst believes that changes or modifications need to be implemented in the contemporaneous project schedules during the analysis, it should be noted that MIP 3.4, is a “self-correcting” analysis since it uses each of the successive contemporaneous schedule updates rather than progressing a single schedule.

Finally, the analyst must also be consistent and maintain independence and objectivity. The analyst cannot limit corrections to those that have the affect of improving the analyst’s client’s position.

One option is to run the analysis two ways. The first run of the analysis would use the schedules as they existed contemporaneously, or unaltered. The second run of the analysis would use the schedule with the minor correction. This approach allows the finder of fact to see the difference, understand the proposed minor modification, and make a reasoned decision without having to guess what the difference would have been between the performing the analysis with the unaltered schedule and with the corrected schedule.

L. Summary of Considerations in Using the Minimum Protocol
• Allows for easier identification of schedule slippage and gains due to schedule revisions and other non-progress factors compared to MIP 3.3

• Cannot be implemented if contemporaneous schedule updates do not exist.

• Uses as the primary tool a set of contemporaneous schedules that are already familiar to the parties at dispute.

• Can enhance credibility if it can be shown that the project participants used the contemporaneous schedules in managing and constructing the project.

• Accounts for the dynamics of evolving events and conditions because it considers the real-time perspective of project conditions, the state of mind, and knowledge of the project participants during each update period.

• Considers the dynamic nature of the critical path because it identifies shifts in the critical path between the updates.

• Delays or savings in time can be assigned to specific activities.

• Data preparation process may be quicker than other methods that require a separate as-built schedule.

• This method can be used to identify and specifically quantify acceleration.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

• The analyst may determine that the critical path responsible for project delays and gains, in hindsight, may be different from that indicated as the planned critical path shown in the contemporaneous schedule updates. Contemporaneous documentation should be provided with the analysis to support any instance of this determination.

• To yield accurate results, the contemporaneous schedule updates used in the analysis must be validated as accurate both in reported progress, according to SVP 2.2, and in the network’s representation of contemporaneous means and methods, according to SVP 2.3.

• If date constraints were liberally used in the update schedules, analysis may be very difficult.

3.5. Observational / Dynamic / Modified or Recreated (MIP 3.5)

A. Description

MIP 3.5 looks like MIPs 3.3 or 3.4 except that it uses contemporaneous schedule updates that were extensively modified or ‘updates’ that were completely recreated. MIP 3.5 is usually implemented when contemporaneous updates are not available or never existed. The fact that it does not use the contemporaneous updates places this method in a fundamentally different category from the standpoint of the nature of source input data.

It is a retrospective technique that uses the modified or recreated schedule updates to quantify the loss or gain of time along a logic path that was or became critical and identify the activities responsible for the critical delay or gain. Although this method is a retrospective technique, it relies on the forward-looking calculations made at the time the updates would have been prepared. That is, it primarily uses the information to the right
of the updates’ data date.

While MIP 3.5 is still categorized as an observational technique since it does not involve the insertion or deletion of delays, it is not purely observational when seen in the context of the level of data intervention by the analyst. MIP’s 3.3 and 3.4 are purely observational in the sense that the analyst is interpreting what is observed in the behavior of the network from update to update and measuring schedule variances based on unaltered, existing logic models. Because of extensive data intervention by the analyst when using MIP 3.5, the observation is made on the behavior of the networks on which the analyst had significant control.

If there were non-progress revisions to the baseline during the project, the method must recognize those non-progress revisions. Otherwise, the modification or the reconstruction is not complete or proper. As such, a properly implemented MIP 3.5 is considered a Dynamic Logic method. If non-progress revisions did not occur on the project, the results of MIP 3.5 would be very similar to one that would result from MIP 3.2.

MIP 3.5 can be implemented with or without the half-step process. Unlike the contemporaneous MIP’s 3.3 and 3.4, the label ‘as-is’ is an irrelevant distinction from the ‘split.’ This is because the modification or reconstruction is under the control of the analyst.

Note that an implementation can be a mixture of some MIP 3.3/3.4 and some MIP 3.5 if some contemporaneous schedules are used and some non-contemporaneous ones are newly created. This occurs often when there are large gaps in the record of contemporaneous updates due to data loss or the fact that updates were not performed for a long period of time during the project. Therefore, just because some schedules used for the analysis are not contemporaneous, it does not necessarily make the entire method an MIP 3.5

**B. Common Names**

1. Update analysis
2. Reconstructed update analysis
3. Modified update analysis
4. Month-to-month
5. Window analysis
6. Windows analysis

**C. Recommended Source Validation Protocols**

1. Implement SVP 2.3 (update validation) and,
2. Implement SVP 2.3 D.1 or D.2 (reconstruction) and,
3. Implement SVP 2.1 (baseline validation).

**D. Enhanced Source Validation Protocols**

1. Implement SVP 2.2 (as-built validation)
2. Implement SVP 2.4 (identification of delay events)

E. Minimum Recommended Implementation Protocols

1. Recognize all contract time extensions granted.

2. Identify the critical path activity that will be used to track the loss or gain of time for the overall network.

3. Determine whether evaluations will be done on all periods or grouped periods as described in Subsection 3.3.K.

4. Every update may not be used. However, every update should be considered. Accuracy is reduced if updates are not evaluated for multiple-month periods when schedule revisions or changes in sequence occurred to the project plan.

5. Separately identify activities that will be used to track intra-network time losses and gains, such as on interim milestones.

6. Compare the update at the start of the analysis period to the update at the end of the analysis period.

7. Use both the longest path and the least float criteria to identify the controlling chain of activities.

8. Identify changes (gained or lost time) in overall Project completion date based on the critical path activity identified in 3.4.E.2, and if necessary.

9. Identify start and finish variances of critical and near-critical activities in the analysis period.

10. Identify all changes and/or revisions to logic, durations, and/or progress that were made during analysis period.

11. Identify responsibility for delays and gains during analysis period.

12. Continue with implementation until all periods are complete.

13. Sum the net gains and losses for each period to arrive at an overall impact to the project. The sum of the net impacts must be equal to difference between the first schedule update and last schedule update used in the evaluation.

F. Enhanced Implementation Protocols

1. Daily Progress Method

   (See Subsection 3.3.F.1)

G. Identification of Critical and Near-Critical Paths

- Identify and understand all related contractual language.

- Identify the negative float theory being used by the opposing analyst.

- For each analysis interval, identify the calculated critical path using the longest path and the lowest total
float concept of the validated update(s) corresponding to the analysis interval.

- The near-critical activity-set in each analysis interval is the one that yields the most number of activities using one of the following methods:
  - lowest float value in the update PLUS the average duration of all discrete delay events contained in whole or in part inside the analysis interval, or
  - lowest float value in the update PLUS duration of the analysis interval.

H. Identification and Quantification of Concurrent Delays and Pacing

- Determine whether compensable delay by contractor or owner is at issue.
- Identify and understand all related contractual language.
- For each delay event, distinguish the cause from the effect of delay.
- Determine whether literal or functional concurrency theory is to be used.
- If applicable, determine the near-critical threshold (see Subsection 4.3).
- If applicable, determine the frequency, duration, and placement of the analysis intervals.
- For each analysis interval, identify the critical path(s) and the near-critical path(s) and explain all relative delayed starts and extended duration of activities that occurred in the previous analysis interval on the same chains of activities.
- In cases where the difference in full-hindsight approach versus ‘blindsight’ approach results in a significance variance, use both approaches for evaluation of concurrency.
- For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.
- For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

(See MIP 3.3.)

J. Identification and Quantification of Mitigation / Constructive Acceleration

(See MIP 3.3.)

K. Specific Implementation Procedures and Enhancements

1. Fixed Periods

The analysis periods are of virtually identical duration and may coincide with regular schedule update periods. Note that the fixed period implementation can be further processed into Grouped or Blocked
implementation as described in MIP’s 3.3 and 3.4.

2. Variable Periods

The analysis periods are of varying durations and are characterized by their different natures such as the type of work being performed, the types of delaying influences, or the operative contractual schedule under which the work was being performed.

3. Fixed-Periods vs. Variable-Periods

Similar to the comparison between the all-periods implementation and the grouped-periods implementation for MIP’s 3.3 and 3.4, a frequent-fixed-periods implementation yields more information than the infrequent-variable-periods implementation, and is considered more precise. The infrequent-variable-periods implementation allows the analyst to skip over periods that may be unfavorable to the party for which the analysis is being performed.

L. Summary of Considerations in Using the Minimum Protocol

- Able to simulate MIP’s 3.3 and/or 3.4 without the benefit of reliable contemporaneous schedule updates if update modification and/or reconstruction is reliable.
- Requires, at the least, a baseline schedule and a reliable source of as-built dates.
- Typically, the smaller the number of modifications to the contemporaneous schedule updates, the more credible the results of the analysis.
- Allows for the consideration of the dynamic nature of the critical path because it identifies shifts in the critical path between the updates even if reliable contemporaneous schedule updates do not exist.
- Allows for the use of hindsight progress updates to simulate the actual critical path.
- Delays can be assigned to specific activities.
- Data preparation process may be quicker than other methods that require compilation of a separate detailed as-built schedule.
- This method can be used to identify acceleration.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

- Where updates are recreated, it is perceived to be an after-the-fact analysis that fails to consider logic changes that would have been incorporated in view of contemporaneous project circumstances.
- Does not have the benefit of source schedules that are already familiar to the parties at dispute.
- To be credible, recreated schedule updates must be accurate both in reported progress to date and in the network’s representation of contemporaneous means, and consistent with other project documentation during the update periods reflecting the real-time perspective of project conditions, the state of mind, and knowledge of the project participants.
- Progress reported for activity performance spanning more than one period must be supported by
reasonable means.

- Relatively time consuming and therefore costly to implement compared to MIP’s 3.3 or 3.4 because it requires substantial support to justify the modifications or the reconstruction.

- The analyst should anticipate significantly more scrutiny and challenges regarding the reliability of the data and logic.

- The analyst may determine that the critical path responsible for project delays and gains, in hindsight, may be different from that indicated as the planned critical path shown in the contemporaneous schedule updates. Contemporaneous documentation should be provided with the analysis to support any instance of this determination.

- Except with very simple network models, it may be difficult to distinguish schedule variances caused by non-progress revisions from schedule variances caused purely by insufficient progress. The reliability of the project documentation to support distinguishing non-progress revision variances from insufficient progress variations will affect the reliability of the analysis.

3.6. Modeled / Additive / Single Base (MIP 3.6)

A. Description

MIP 3.6 is a modeled technique since it relies on a simulation of a scenario based on a CPM model. The simulation consists of the insertion or addition of activities representing delays or changes into a network analysis model representing a plan to determine the hypothetical impact of those inserted activities to the network. Hence, it is an additive model.

![Diagram of Modeled, Additive, Single Base](image-url)

Figure 5 – Graphic Example: Modeled, Additive, Single Base
MIP 3.6 is a single base method, distinguished from MIP 3.7 as a multiple base method. The additive simulation is performed on one network analysis model representing the plan. Hence, it is a static logic method as opposed to a dynamic logic method.

MIP 3.6 can be used prospectively or retrospectively. Prospectively, it can be used to forecast future impacts; for description and implementation\(^7\), see AACE Recommended Practice 52R-06 Time Impact Analysis – As Applied in Construction. Retrospectively, as described here, it relies on the forward-looking calculations to the right of the data date.

**B. Common Names**

1. Impacted as-planned (IAP)
2. Impacted baseline (IB)
3. Plan plus delay
4. Impacted update analysis
5. Time impact analysis (TIA)
6. Time impact evaluation (TIE)
7. Fragnet insertion
8. Fragnet analysis

**C. Recommended Source Validation Protocols**

1. Implement SVP 2.1 (baseline validation) or,
2. Implement SVP 2.3 (update validation) and,
3. Implement SVP 2.4 (delay ID and quantification).

**D. Enhanced Source Validation Protocols**

1. Implement SVP 2.2 (as-built validation)

**E. Minimum Recommended Implementation Protocols**

1. Recognize all contract time extensions granted.
2. Identify and quantify delays that are to be evaluated, including source documents on which they are based.
3. Select the planned network to be utilized as the “un-impacted schedule”. If not using the baseline, select the contemporaneous update that existed just prior to the initial delay that is to be evaluated. Unless very accurate daily project documentation data is available, there is generally no improvement in analysis accuracy with an attempt to status the update schedule to the beginning of the delay(s) over the use of

\(^7\) See AACE Recommended Practice No. 52R-06 Time Impact Analysis – As Applied in Construction.
the analysis update statused to the data date used for the selected period

4. Insert an activity or activities (fragnet) into the “un-impacted schedule” to represent the selected delay(s).

5. Calculate or schedule the new schedule created by the “un-impacted schedule” with the fragnet or activity inserted. In the most basic implementations (i.e. bar chart evaluation) it may be necessary to calculate the impact by hand. The resultant network is considered the “impacted schedule”.

6. Zero out the durations of all activities in the added fragnet and verify that when calculated, there is no change to the completion date from the un-impacted schedule completion date. This verifies that there is no added logic in the fragnet that creates a delay.

7. Ensure that the resulting schedule has at least one continuous critical path, using the longest path criterion that starts at NTP or some earlier start milestone and ends at a finish milestone, which is the latest occurring schedule activity in the network, after the insertion of delay activities.

8. Compare the Project completion date of the impacted and un-impacted schedules to determine the impact of the inserted fragnet(s).

9. Tabulate and justify each change made to the baseline used to create the impacted as-planned.

10. Use both the longest path and the least float criteria to identify the controlling chain of activities.

11. Quantify net delays and gains.

F. Enhanced Implementation Protocols

1. Analysis accompanied by a listing of known significant delays that are not incorporated into the model.

2. Compare the impacted schedule to the as-built and explain the variances between the two schedules for all significant chains of activities.

G. Identification of Critical and Near-Critical Paths

- Identify and understand all related contractual language.

- Identify the negative float theory being used by the opposing analyst.

- From the baseline schedule, identify the calculated critical path of the baseline using the longest path and the lowest total float concept of the validated baseline.

- The near-critical activity-set is the one that yields the most number of activities using one of the following methods:
  - the lowest float value in the pre-insertion baseline network PLUS the maximum duration of all the inserted delays, or
  - the float value of the pre-insertion baseline longest path PLUS the maximum duration of all the inserted delays, or
  - the lowest float value in the pre-insertion baseline PLUS the average duration of the periods of
schedule updates or revisions generated during the project.

- Stepped insertion should be in chronological order of the occurrence of the delay event.

**H. Identification and Quantification of Concurrent Delays and Pacing**

In its minimum implementation, concurrency cannot be evaluated by this method. The procedure below outlines some enhancements over the minimum implementation that would allow limited evaluation of concurrent delays using this method.

- Determine whether compensable delay by contractor or owner is at issue.
- Identify and understand all related contractual language.
- For each delay event, distinguish the cause from the effect of delay.
- Determine whether literal or functional concurrency theory is to be used.
- If applicable, determine the near-critical threshold (see Subsection 4.3).
- If applicable, determine the frequency, duration, and placement of the analysis intervals.
- Compare the pre-insertion baseline to the as-built and discretely identify and classify by causation all delays on those chains of activities that are near-critical in the pre-insertion baseline schedule.
- Insert the delays found in the previous step into the pre-insertion baseline and compare the result with the impacted baseline that resulted from the insertion of the claimed delays.
- For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.
- For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

**I. Determination and Quantification of Excusable and Compensable Delay**

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings resulting from analyses performed under this RP.

Absent contract language or other agreements, use the following procedure to determine the net total delay apportionment:

1. **Excusable and Compensable Delay (ECD)**

   An additive-modeled schedule by itself does not account for concurrent delays and is therefore unsuitable for determining compensability to the claimant. However, it is possible to analyze for approximate concurrency by comparing two additive-modeled schedules. To do this:

   a. Create one additive model by inserting all owner-caused and *force majeure*-caused impact events into the baseline.
Create another additive model by inserting all contractor-caused impact events into the baseline.

b. Compare the two resulting schedules. To the extent that the net delay-effect beyond the baseline completion date overlaps, there is concurrency.

c. The extent to which the completion date of the additive model with the owner-impact is later than that of the other additive model with the contractor-impact, may be the quantity of ECD, but only to the extent that the impacted completion date does not exceed the actual completion date.

2. Non-Excusable and Non-Compensable Delay (NND)

An additive-modeled schedule by itself does not account for concurrent delays and is therefore unsuitable for determining compensability to the respondent or liquidated/stipulated damages. However, it is possible to analyze for approximate concurrency by comparing two additive-modeled schedules. To do this:

a. Create one additive model by inserting all owner-caused and force majeure-caused impact events into the baseline.

b. Create another additive model by inserting all contractor-caused impact events into the baseline.

c. Compare the two resulting schedules. To the extent that the net delay-effect beyond the baseline completion date overlaps there is concurrency.

d. The extent to which the completion date of the additive model with the contractor-impact is later than that of the other additive model with the owner-impact, may be the quantity of NND, but only to the extent that the impacted completion date does not exceed the actual completion date.

3. Excusable and Non-Compensable Delay (END)

a. Insert all owner-caused and force majeure-caused impact events into the baseline and recalculate the schedule.

b. The difference between the baseline completion of the longest path and the completion of the longest path in the additive model is the END.

c. If the completion of the longest path in the additive model is later than the actual completion date, the END is the difference between the baseline completion and the actual completion dates.

J. Identification and Quantification of Mitigation / Constructive Acceleration

The comparison between the completion date of the longest path of the additive model and the actual completion date will provide a gross approximation of acceleration or delay mitigation. This is based on the theory that if non-contractor delays inserted into the baseline yield a completion date that is later than that actually achieved, it must have resulted from shortening of actual performance duration and/or the use of more aggressive logic. Note that the gross comparison does not provide the detail necessary in order to address the issue of who gets the credit for the acceleration.

K. Specific Implementation Procedures and Enhancements

1. Global Insertion
Once the Baseline Schedule is identified then all known delaying events are added to this schedule. In the global insertion method, all delay events and influences are added together and the impact is determined on the combined effect of the added delays. If the analyst is trying to document the total impact of all delay events then insertion of all events at one time may accomplish this task.

2. Stepped Insertion

The delays are added individually or in groups to the Baseline Schedule and the impact is determined after each iterative insertion. If the analyst is concerned with the impact of each delay event then the events should be inserted in chronological order of occurrence of the event in order to reflect actual circumstances if the events are introduced into the delay analysis individually, the impacted completion date should be recorded after each delay is included.

For each delay event introduced into this analysis one must be able to document the duration of the delay, and the predecessor and successor activities related to the delay, in order to perform this method objectively.

L. Summary of Considerations in Using the Minimum Protocol

- Suited primarily for the use in identifying and quantifying potential delays rather than actual delays.
- This method can be used to quantify non-compensable time extensions, but cannot, by itself, quantify compensable delays because it does not account for concurrent or pacing delays.
- This method can be used to identify acceleration, although actual performance that is better than predicted by use of this method does not, in and of itself, necessarily demonstrate active implementation of acceleratory measures.
- Intuitively easy to understand and present, and can be understood especially by those that do not have a construction background.
- Does not require an as-built schedule or contemporaneous schedule updates.
- Can be implemented relatively easily and quickly compared to other MIP’s, but is of limited reliable use.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

- Because it does not rely on as-built data, it is a hypothetical model, especially where the project is actually constructed differently than the baseline schedule logic.
- Susceptible to unintended or intended manipulation due to modeling if only one party’s delays are considered, since the method cannot account for the impact of delays not explicitly inserted.
- Accuracy of the duration of critical path impact for any given delay event degrades in proportion to the chronological distance of the delay event from the data date of the schedule.
- Since it relies only on the initial as-planned critical path to analyze delays, it does not account for changes in logic or durations of activities
- Does not necessarily consider the chronological order of delays.
• Extremely sensitive to the order of fragnet and logic insertion.

3.7. Modeled / Additive / Multiple Base (MIP 3.7)

A. Description

MIP 3.7 is a modeled technique since it relies on a simulation of a scenario based on a CPM model. The simulation consists of the insertion or addition of activities representing delays or changes into a network analysis model representing a plan to determine the hypothetical impact of those inserted activities to the network. Hence, it is an additive model.

MIP 3.7 is a multiple base method, distinguished from MIP 3.6 as a single base method. The additive simulation is performed on multiple network analysis models representing the plan, typically an update schedule, contemporaneous, modified contemporaneous, or recreated. Each base model creates a period of analysis that confines the quantification of delay impact.

Because the updates typically reflect non-progress revisions, it is a dynamic logic method as opposed to a static logic method.

MIP 3.7 is a retrospective analysis since the existence of the multiple periods means the analyst has the benefit of hindsight.

B. Common Names

1. Window analysis
2. Windows analysis
3. Impacted update analysis
4. Time impact analysis (TIA)
5. Time impact evaluation (TIE)
6. Fragnet insertion
7. Fragnet analysis

C. Recommended Source Validation Protocols

1. Implement SVP 2.1 (baseline validation) and,
2. Implement SVP 2.3 (update validation) and,
3. Implement SVP 2.4 (delay ID and quantification)

D. Enhanced Source Validation Protocols

1. Implement SVP 2.2 (as-built validation)

E. Minimum Recommended Implementation Protocols
1. Recognize all contract time extensions granted.

2. Identify and quantify delays that are to be evaluated, including source documents on which they are based.

3. Select the as-planned network to be utilized as the “un-impacted schedule”. If not using the baseline, select the contemporaneous update that existed just prior to the initial delay that is to be evaluated.

4. Identify the schedule updates, or recreated updates, that correlate to the beginning of each analysis interval. Unless very accurate daily project documentation data is available, there is generally no improvement in analysis accuracy with an attempt to status the update schedules to the beginning of the delay(s) over the use of the analysis updates statused to the data dates used for each period.

5. Insert an activity or activities (fragnet) into the “un-impacted schedule” to represent the selected delay(s). Ensure that the impact events are chronologically inserted into the proper updated schedules.

6. Calculate or schedule the new schedule created using the “un-impacted schedule” with the fragnet or activity inserted. In the most basic implementations (i.e. bar chart evaluation) it may be necessary to calculate the impact by hand. The resultant network is considered the “impacted schedule”.

7. Zero out the durations of all activities in the added fragnet and verify that when calculated, there is no change to the completion date from the un-impacted schedule completion date. This verifies that there is no added logic in the fragnet that creates a delay situation.

8. Ensure that the resulting schedule has at least one continuous critical path, using the longest path criterion that starts at NTP or some earlier start milestone and ends at a finish milestone, which is the latest occurring schedule activity in the network, after the insertion of delay activities.

9. Tabulate and justify each change made to an update schedule to create the impacted schedule. Insert model fragnets in the correct updated schedule containing previous impacts, period by period.

10. Use both the longest path and the least float criteria to identify the controlling chain of activities.

11. A new analysis period needs to be established with each significant change in the critical path chain of activities, and with each available contemporaneous update schedule.

12. Correlate the impacted schedule with each available contemporaneous update, identifying and using either hindsight or blindsight for establishing remaining durations for the incomplete fragnet activities.

13. Quantify net delays and gains.

14. Prepare a tabulation that summarizes the variances quantified for each analysis period and reconcile the total to the result that would be obtained by a competent implementation of MIP 3.1.

**F. Enhanced Implementation Protocols**

1. Analysis is accompanied by a listing of known significant delays not incorporated into the model.

2. Compare the impacted schedule to the as-built and explain the variances between the two schedules for all significant chains of activities.

3. Use accepted baseline, updates and schedule revisions.
G. Identification of Critical and Near-Critical Paths

- Identify and understand all related contractual language.
- Identify the negative float theory being used by the opposing analyst.
- For each analysis interval, identify the calculated critical path using the longest path and the lowest total float concept of the pre-insertion validated update(s) corresponding to the analysis interval.
- The near-critical activity-set in each analysis interval is the one that yields the most number of activities using one of the following methods:
  - float value of the longest path in the pre-insertion validated update PLUS the maximum duration of all discrete delay events inserted in whole or in part inside the analysis interval, or
  - lowest float value in the pre-insertion validated update PLUS the maximum duration of all discrete delay events inserted in whole or in part inside the analysis interval, or
  - lowest float value in the update PLUS duration of the analysis interval.
- Stepped insertion should be in chronological order of the occurrence of the delay event.

H. Identification and Quantification of Concurrent Delays and Pacing

- Determine whether compensable delay by contractor or owner is at issue.
- Identify and understand all related contractual language.
- For each delay event, distinguish the cause from the effect of delay.
- Determine whether literal or functional concurrency theory is to be used.
- If applicable, determine the near-critical threshold (see Subsection 4.3.)
- If applicable, determine the frequency, duration, and placement of the analysis intervals.
- For each analysis interval, compare the pre-insertion schedule update(s) corresponding to the analysis interval to the as-built, and discretely identify and classify by causation all delays on those chains of activities that are near-critical in the pre-insertion schedule update.
- Insert those discrete delay activities into the pre-insertion update and compare the result of the impacted schedule to the un-impacted schedule for that analysis interval that resulted from the insertion of the claimed delays.
- Compare the longest path of the impacted schedule for the analysis interval with the longest path of the same schedule recalculated with the progress data and the data date of the subsequent analysis interval. If the longest path and the overall completion dates are the same, the predictive model generated for the analysis period is reasonably accurate.
- If the longest path is the same but the overall completion date of the progressed version is later, the delay predicted for the longest path was, in actuality, worse, or additional delay events occurred on the longest
path.

- If the longest path is the same but the overall completion date of the progressed version is earlier, there was acceleration or some other delay mitigation on the delays on the longest path.

- If the longest path and the overall completion dates are the same but an additional path is also the longest path, some activity or delay event on that additional longest path may be concurrent with the claimed delay.

- If the longest path has changed but the overall completion date is the same, some activity or delay event on the new longest path may be partially or completely concurrent with the claimed delay on the former longest path.

- If the longest path has changed but the overall completion date is earlier, some activity or delay event on that new longest path may be partially or completely concurrent with the claimed delay on the former longest path.

- If the longest path has changed but the overall completion date is later, some activity or delay event on that new longest path may be partially or completely concurrent with the claimed delay on the former longest path.

- Compare the longest path of the progressed version of the analysis interval with the longest path of the pre-insertion baseline of the subsequent analysis interval. Any differences are the result of non-progress revisions implemented in the pre-insertion baseline of the subsequent analysis interval and should be identified and explained.

- Repeat the process for all analysis intervals.

- For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.

- For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings resulting from analyses performed under this RP. Note that this method or a variation of this is often specified as the method of choice in many construction contracts, including specific procedural steps for implementation. Therefore, the following procedure should be applied only in absence of contract language or other agreements.

1. **Excusable and Compensable Delay (ECD)**

An additive-modeled schedule by itself does not account for concurrent delays and is therefore unsuitable for determining compensability. However, it is possible to analyze for concurrency by comparing two additive-modeled schedules. The reliability of this quantification method is inversely proportional to the duration of the analysis periods. In other words, the shorter the period duration, the more reliable the quantification. See Subsection 4.2.D.4.
To do this, for each analysis period:

a. Create one additive model by inserting the subject owner-caused and *force majeure*-caused impact events into the update with the data date closest in time prior to the commencement of the impact event.

b. Create a separate additive model by inserting the contractor-caused impact events into the same update chosen for the owner-impact model.

c. Compare the two resulting schedules. To the extent that the net delay-effect beyond the baseline completion date overlaps there is concurrency.

d. The extent to which the completion date of the additive model with the owner-impact is later than that of the other additive model with the contractor-impact, *may* be the quantity of ECD, but only to the extent that the impacted completion date does not exceed the actual completion date.

2. **Non-Excusable and Non-Compensable Delay (NND)**

An additive-modeled schedule by itself does not account for concurrent delays and is therefore unsuitable for determining compensability. However, it is possible to analyze for concurrency by comparing two additive-modeled schedules. The reliability of this quantification method is inversely proportional to the duration of the analysis periods. In other words, the shorter the period duration, the more reliable the quantification. See Subsection 4.2.D.4.

To do this, for each analysis period:

a. Create one additive model by inserting the subject contractor-caused impact events into the update with the data date closest in time prior to the commencement of the impact event.

b. Create a separate additive model by inserting the owner-caused and *force majeure*-caused impact events into the same update chosen for the owner-impact model.

c. Compare the two resulting schedules. To the extent that the net delay-effect beyond the baseline completion date overlaps there is concurrency.

d. The extent to which the completion date of the additive model with the contractor-impact is later than that of the other additive model with the owner-impact, *may* be the quantity of NND, but only to the extent that the impacted completion date does not exceed the actual completion date.

3. **Excusable and Non-Compensable Delay (END)**

a. Insert the owner-caused and *force majeure*-caused impact events into the update with the data date closest in time prior to the commencement of the impact event.

b. The difference between the completion of the longest path prior to the insertion and the completion of the longest path after the insertion is the END.

c. The post-insertion schedule can be further analyzed by inserting actual progress data. If the resulting completion date is shorter than that indicated in the post-insertion schedule prior to actual progressing, it may be proper to reduce the amount of END accordingly.
J. Identification and Quantification of Mitigation / Constructive Acceleration

In MIP 3.7, after inserting delays into the update closest in time preceding the delay, the identity and the movement of the critical path is monitored. Then, when the update is progressed with actual progress data and the same logic path reexamined, if the logic path is shorter than that which was calculated prior to adding actual progress, there was acceleration or schedule recovery during the period for which actual progress was entered.

K. Specific Implementation Procedures and Enhancements

1. Fixed Periods

The analysis periods are of virtually identical duration and may coincide with regular schedule update periods.

2. Variable Periods

The analysis periods are of varying durations and are characterized by their different natures such as the type of work being performed, the types of delaying influences, significant project events, changes to the critical path, revised baseline schedules, and/or the operative contractual schedule under which the work was being performed.

3. Global Insertion

All the delay events and influences are added together and the impact is determined on the combined effect of the added delays.

4. Stepped Insertion

The delays are added individually or in groups and the impact is determined after each iterative insertion. Note that stepping is different from inserting the delays in time period groups that create a straight, vertical delineation of analysis periods; whereas, delays for each step insertion may not fit neatly into an existing analysis period.

L. Summary of Considerations in Using the Minimum Protocol

- Considers the chronological order of delays better than MIP 3.6.

- Can be performed relatively easily throughout the life of the project for project control when implemented as the AACE Recommended Practice 52R-06, Time Impact Analysis, as well as for forensic use as described in this recommended practice.

- Takes into consideration changes to the critical path as they occur on the project

- Requires routine schedule updates performed throughout project life.

- This method can be used to quantify non-compensable time extensions, but cannot, by itself, quantify compensable delays because it does not account for concurrent or pacing delays.

- This method can be used to identify and quantify acceleration, although actual performance that is better than predicted by use of this method does not, in and of itself, necessarily demonstrate active implementation of acceleratory measures.
• Does not require an as-built schedule.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

• Because it does not rely on as-built data, it is a hypothetical model, especially where the project is actually constructed differently than the baseline schedule logic. However, compared to MIP 3.6, the periodic nature of the analysis incorporates as-built data.

• Susceptible to unintended or intended manipulation due to modeling if only one party’s delays are considered, since the method cannot account for the impact of delays not explicitly inserted.

• Accuracy of the duration of critical path impact for any given delay event degrades in proportion to the chronological distance of the delay event from the data date of the schedule.

• Labor intensive in comparison to MIP 3.6 when implemented properly because of the additional source schedules and technical complexity.

• Extremely sensitive to the order of fragnet and logic insertion.

3.8. Modeled / Subtractive / Single Simulation (MIP 3.8)

A. Description

3.8 is a modeled technique relying on a simulation of a scenario based on a CPM model. The simulation consists of the extraction of entire activities or a portion of the as-built durations representing delays or changes from a network analysis model representing the as-built condition of the schedule to determine the impact of those extracted activities on the network. Hence, it is a subtractive model.

Figure 6 – Graphic Example: Modeled, Subtractive, Single Simulation

The subtractive simulation is performed on one network analysis model representing the as-built. Because it uses one network analysis model, it is technically a static logic method as opposed to a dynamic logic method.
But, recall that the significance of the distinction rests in the fact that the project undergoes non-progress revisions reflecting the as-built conditions in contrast to the original baseline logic. And in view of that, a method that dynamically considers how the original logic changed is thought to be more forensically accurate than that which statically relies solely on the baseline logic. Therefore, in that context, the distinction in the case of MIP 3.8 is irrelevant since it relies on the as-built as the starting point.

MIP 3.8 is primarily used retrospectively.

B. Common Names

1. Collapsed as-built (CAB)
2. But-for analysis
3. As-built less delay
4. Modified as-built

C. Recommended Source Validation Protocols

1. Implement SVP 2.2 (as-built validation) and,
2. Implement SVP 2.4 (delay ID and quantification)

D. Enhanced Source Validation Protocols

1. Implement SVP 2.1 (baseline validation)
2. Implement SVP 2.3 (update validation)

E. Minimum Recommended Implementation Protocols

1. The as-built schedule model from which the delays are extracted is CPM logic-driven as opposed to a graphic as-built schedule. Therefore the calculated early start and early finish dates in the as-built schedule model match the actual start and actual finish dates; and, the collapsed schedule after delay extraction should also be CPM logic-driven.

2. Each change made to the as-built schedule model to create the collapsed schedule is tabulated and justified.

3. Reconcile all contract time extensions granted.

4. The as-built schedule model should contain:
   a. As-built critical path activities found in implementing Subsection 4.3 including near-critical and near-longest paths.
   b. Baseline critical path and longest path.
   c. All contractual milestones and their predecessor chains.
d. All chains of activities alleged by the respondent to have constituted critical claimant-caused delays or concurrent delays due to specific fault of the claimant.

e. All delays for which contract time extensions were granted.

5. The collapsing process should not involve any adjustment to logic, including lag values, or removal of constraints unless each instance of such adjustment is specifically tabulated and the basis of such adjustment explained.

6. Perform a constructability analysis of the resulting collapsed as-built schedule.

F. Enhanced Implementation Protocols

1. Reconcile the as-built and the collapsed as-built to the as-planned schedule.

2. Use all schedule activities found in the baseline schedule.

3. To account for periods during which work could not have progressed under the collapsed scenario, use a calendar simulating actual weather conditions.

G. Identification of Critical and Near-Critical Paths

Prior to the extraction of delays, pure computation of the criticality of a schedule activity under the collapsed as-built method is neither practical nor necessary. To fully verify the quantum of compensable delays and to fully account for non-compensable confluences, the analyst must consider and extract the delays and then assess the criticality of the delay. The critical path identified after the extraction process is called the analogous critical path. See Subsection 3.8.K.3

Identification of the near-controlling path at this stage is not necessary if the significant set of as-built activities were properly selected when the as-built model was prepared.

The checklist for the identification of critical and near-critical paths is as follows:

- Identify and understand all related contractual language.
- Identify the negative float theory used by the opposing party.
- If necessary, identify the as-built controlling path(s) using Subsection 4.3.C.
- After extraction of delays, identify the analogous critical path (see Subsection 3.8.K.3).

H. Identification and Quantification of Concurrent Delays and Pacing

Even in its minimum implementation, concurrency analysis is built into this method. Since the as-built, by definition, contains all delays that occurred on the activity paths modeled to the extent that a subset of those delays are extracted, the post-extraction schedule still contains the impact of those delays that were left in the model, thereby accounting for the concurrent impact of those delays. Because of this, often the evaluation of pacing delays is a part of the extraction process. To what extent concurrent delays are evaluated is directly related to the significant set of activities that was integrated into the as-built model.

The checklist for the identification of critical and near-critical paths is as follows:
I. Determination and Quantification of Excusable and Compensable Delay

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings resulting from analyses performed under this RP.

Absent such overriding language, use the following procedure.

1. **Excusable and Compensable Delay (ECD)**

   The difference between the as-built completion date and the collapsed as-built completion date resulting from the extraction of all owner-caused delays is the total ECD. If the owner has paid the contractor specifically to accelerate, then any negative delay durations (delay mitigation) resulting from the owner-paid acceleration should be credited to the owner against the total ECD to avoid double payment to the contractor for acceleration. Where the quantification of the duration of the specific paid mitigation is not reasonably feasible, the credit adjustment may be accomplished by crediting the monetary value of the acceleration payment against the monetary value of the ECD.

2. **Non-Excusable and Non-Compensable Delay (NND)**

   The difference between the as-built completion date and the collapsed as-built completion date resulting from the extraction of all contractor-caused delays is the total NND. If the contractor accelerated or implemented other mitigating measures and the owner did not reimburse the contractor for the cost of mitigation, the net critical mitigation duration should be subtracted from the total NND.

3. **Excusable and Non-Compensable Delay (END)**

   Because entitlement to END does not require that concurrency periods be eliminated, this method is too rigorous for quantifying END since it automatically accounts for concurrency. However, it can be said that the difference between the as-built completion date and the collapsed as-built completion date resulting from the extraction of all owner-caused delays is at least the total END.

J. Identification and Quantification of Mitigation / Constructive Acceleration
The subtractive modeling methods are not the best tools for identifying and quantifying specific instances of acceleration and delay mitigation, since the methods start with the as-built schedule that already incorporates all acceleration measures to the extent that they were actually implemented. When the delays are subtracted the resulting schedule still retains all acceleration measures that were built into the as-built. Therefore, the resulting comparison is that of one accelerated schedule to another, albeit one without delays.

However, the subtractive modeling methods are one of the only tools to identify and quantify the overall extent to which the contractor’s actual performance would have resulted in a project duration shorter than the baseline schedule, but for the delays. If the completion date of the collapsed schedule is earlier than that of the original baseline schedule it can be claimed by the contractor that if allowed to proceed unhindered by delays, it was possible to finish earlier than originally planned. Whether the contractor would have decided to actually incur the necessary expenses to implement the acceleratory measures absent delays must be proven independently of the schedule analysis.

K. Specific Implementation Procedures and Enhancements

1. Choice of Extraction Modes

   a. Global Extraction

      All the delay events and influences are extracted together and the impact is determined on the combined effect of the extracted delays.

   b. Stepped Extraction

      The delays are extracted individually or in groups, and the impact is determined after each iterative extraction. Stepped extraction should be in reverse chronological order of the occurrence of the delay event. This is the reverse of the order recommended for the additive MIP’s 3.6 and 3.7. In the additive methods, the base schedule contains no delays, so it makes sense to start the additive process chronologically. In 3.8 the base schedule already contains all the delays. If extraction is performed chronologically, the iterative results would make no sense. For example, extracting the earliest delay first would create a schedule that still contains all the delays that occurred after the first delay.

2. Creating a Collapsible As-Built CPM Schedule

   a. The first step in modeling the as-built CPM is to determine the actual duration of each schedule activity. In assigning actual durations and actual lead-lag values, use a 7-day week calendar which allows all duration units to be in calendar days rather than working days, the main reason being that often project documentation will reveal that work was performed on some days that were planned to be non-working days. The spillover advantage of using a 7-day calendar is that it significantly simplifies the reconciliation of the calculated results. This system may sometimes produce anomalous results. For example, if work started on Friday and completed on the next Monday, the duration assignment will be four days although only two were actually worked. Then in the collapse, if the same activity happens to start on the first day of a four-day holiday weekend, it will show to continue through the holiday weekend and complete on the last day of the holiday. However, the system tends to balance itself out because it is equally likely that an activity which started on a Friday and finished on the following Monday (a 2 workday activity taking 4 calendar days) would show up as occupying four workdays from a Monday through Thursday in the collapsed as-built. The counterbalancing rule is applicable to both work activities and no-work durations. Hence, the 7-day calendar is often used initially for assigning actual durations to both types of activities. Conversion to
a 7-day calendar, however, may not always be appropriate. For example, when calendars include long non-work periods, such as winter breaks, it may be more appropriate to retain the original project calendars to ensure that the collapsed as-built schedule does not result in work being performed during non-work periods.

b. The as-built schedule, containing actualized data, forms the basis for creating the collapsible As-Built CPM schedule. This bar chart is modified to convert it to a CPM schedule by incorporating actual and underlying unimpacted logic relationships. The purpose of this is to allow the CPM schedule to simulate the actual activity durations and sequences solely by CPM computation using the logic ties and actual durations. The four-series diagram in Figure 7 illustrates this concept.

c. Be aware that in many cases an activity should have more than one predecessor. For example, suppose that the start of wire pulling in building B was controlled by the completion of wire pulling in building A. In such a case, there would be a finish-to-start (FS) relationship with a zero lag value from “pull wire building A” to “pull wire building B”. But the installation of conduit in building B will need to be tied as a logical predecessor to wire pulling, even if that activity may not have been the controlling factor. This non-controlling relationship may become the controlling relationship if the wire pulling for building A collapses to an earlier date than conduit installation for building B.

AS-PLAN LOGIC WITH AS-PLANNED DURATIONS

AS-PLAN LOGIC WITH PROGRESSED ACTUAL DATES

AS-PLAN LOGIC WITH AS-BUILT DURATIONS (WRONG)

AS-BUILT LOGIC WITH AS-BUILT DURATIONS (RIGHT)

Figure 7 – Conversion of As-Planned Logic to As-Built Logic
d. Depending on the level to which the as-built logic has been developed, the activity float value in and of itself, may not be the true computed delineation of the as-built controlling path. This is illustrated in Figure 8 below.

e. The focus is on activity #2. This first model shows a F50 logic tie from activity #2 to activity #4 allowing activity #2 to carry a float value of 5. The diagram below shows that a change to the successor logic of activity #2 to a FF5 to activity #3 will not change the dates but makes activity #2 critical.

Figure 8 – As-Built Logic Showing Activity 2 Not Critical

![Figure 8](image)

Figure 9 – Logic Change to Make Activity 2 Critical

f. Another way of looking at this FF5 logic is to model the 5 days of lag as an explicit schedule activity, and tie that to activity #4 with an F50. While adopting a policy to replace all non-zero lag values with explicit activities and restrict all relationship ties to F50 may simplify the logic and debugging process, it will greatly increase the number of activities to be processed.

g. If the logic change is more reflective of what actually took place, the second model is superior to the first model and is further along in the modeling process. This does not make the first model wrong because the validity of the as-built dates is intact, just the logic and the calculated float have changed. But, to rely solely on the float value of a less developed as-built model may invite error in the determination of the controlling path.

h. In most cases, simulating the actual performance of work using CPM logic requires the use of logic ties other than standard, simple, consecutive finish-to-start ties (FS0). The following is a set of guidelines to be used in assigning CPM logic ties to simulate as-built performance:

i. Replace any FS logic with lag values 50% or longer than the duration of its predecessor or its successor, with a schedule activity.

ii. Replace any SS Logic with lag values 50% or longer than the duration of the predecessor with a schedule activity.
iii. Replace any FF Logic with lag values 50% or longer than the duration of the successor with a schedule activity.

iv. Replace FS logic with negative lag values whose absolute value is larger than one unit of duration, with another type of logic with a zero or a positive lag that does not violate the rules stated above. Some practitioners, however, may elect to allow negative lags if the lag value is small relative to the predecessor activity duration.

v. Replace SS or FF logic with negative lag values whose absolute value is larger than one unit of duration, with another type of logic with a zero or a positive lag that does not violate the rules stated above.

vi. Where more than one type of logic tie is applicable, use the type that would use the smallest absolute lag value as the controlling logic tie.

i. This highlights the importance of this logic process, but do not expect to perfect the logic at this stage. This is due to the fact that the collapsed as-built method is most efficiently implemented as a multi-iterative process involving rapid modeling and a subsequent trial collapse which reveals faulty or incomplete as-built logic. This is repeated until the model is debugged. However, this does not excuse the analyst from using a judicious combination of expert judgment, common sense, and extensive input from project personnel with first-hand knowledge of the day-to-day events during this step of the process.

3. Identification of the Analogous Critical Path (ACP)

The analogous critical path, or ACP, is determined by transferring the calculated critical path of the collapsed as-built onto the logic path of the as-built schedule. After the delays are extracted from the as-built schedule, the remaining critical path is transferred onto the logic path of the as-built schedule. This critical path is called the analogous critical path, or ACP. The analogous critical path allows the analyst to reconcile the total delta between the collapsed state and the as-built state with the sum of those delays, whole or in part, lying on the analogous path.

Because the collapsed as-built schedule is the residual schedule after the extraction of delay activities at issue, a comparison of the critical path of the collapsed as-built with the same logic path on the as-built will yield the list of delays whose discrete durations add up to the net difference in overall duration between the two schedules.

The ACP may or may not be identical to the controlling path. The paths are identical if the sum of the delays along the controlling path is equal to the duration difference between the as-built and the collapse. A rule that can be derived from this is that the sum of delays along the ACP is equal to or less than those on the controlling path, but never more. The converse of this rule is that if a delay that does not lie on the ACP but is on the controlling path and was not extracted out of the as-built, a full collapse may not be achieved to the extent the duration of the particular delay exceeds the arithmetic difference between the sum of the delays on the ACP and the sum of all delays on the subject controlling path.

L. Summary of Considerations in Using the Minimum Protocol

- Concept is intuitively easy to understand and present.
- Can isolate owner and/or contractor-caused delays if there is sufficient detail in the as-built schedule.
3.9. Modeled / Subtractive / Multiple Base (MIP 3.9)

A. Description

Like MIP 3.8, MIP 3.9 is a modeled technique relying on a simulation of a CPM model scenario. The simulation consists of the extraction of entire activities or a portion of the as-built durations representing delays or changes from a network analysis model representing the as-built condition of the schedule to determine the impact of those extracted activities to each network model. Hence, MIP 3.9 is also a subtractive model.

MIP 3.9 is a multiple base method, distinguished from MIP 3.8 which is a single base method. The subtractive simulation is performed on multiple network analysis models representing the as-built schedule, typically updated schedules, which may include contemporaneous, modified contemporaneous, or recreated schedules. As the project undergoes non-progress revisions in reaction to the as-built conditions, in contrast to the original baseline logic, MIP 3.9 considers those logic changes and, therefore, is thought to be more attuned to the perceived critical path, in addition to the actual critical path that existed during the project than methods which rely solely on the initial baseline or the final as-built. Because the updates typically include non-progress revisions, MIP 3.9 is a dynamic logic method as opposed to a static logic method.

The subtractive simulation is performed on periodic network analysis models representing intervals of the as-built schedule. Each model creates a time period of analysis that confines the quantification of delay impact. Forecasted delays beyond an analysis period, however, may also need to be extracted at the time that the
forecasted delays are introduced into the schedule. For example, a schedule update may include a change order impact inserted into the update to forecast delay events which is expected to occur several months after the schedule update period. This may distort the delay calculations when compared with the previous schedule being used as the baseline for the analysis. Thus, these forecasted impacts may need to be removed from the analysis period under consideration in order to properly quantify current impacts.

MIP 3.9 shares an important technical consideration with MIP 3.5 (Observational / Dynamic / Modified or Recreated), namely the choice in using hindsight or blindsight in recreating, and in the case of MIP 3.9, modeling activities that were partially complete on a given data date.

MIP 3.9 is primarily used retrospectively.

**B. Common Names**

1. Collapsed As-Built (CAB)
2. Windows Collapsed As-Built
3. But-For Analysis
4. Windows As-Built But-For
5. As-Built Less Delay
6. Modified As-Built
7. Look-Back Window

**C. Recommended Source Validation Protocols**

1. Implement SVP 2.2 (as-built validation),
2. Implement SVP 2.3 (update validation) and,
3. Implement SVP 2.4 (delay ID and quantification)

**D. Enhanced Source Validation Protocols**

1. Implement SVP 2.1 (baseline validation)

**E. Minimum Recommended Implementation Protocols**

1. The as-built schedule models from which the delays are extracted are CPM logic-driven as opposed to graphic as-built schedules. Therefore the calculated early start and early finish dates in the as-built schedule models match the actual start and actual finish dates and the collapsed schedules after delay extraction should also be CPM logic-driven.

2. Each change made to the as-built portion of the schedule for each time period to create the collapsed schedule is tabulated and justified.

3. There should be at least two base models, consisting of one based on a partially progressed schedule
update and a second one based on a fully progressed schedule update or an as-built schedule.

4. The as-built schedule models should contain:
   a. As-built critical path activities found in implementing Subsection 4.3 including near-critical and near-longest paths.
   b. Baseline critical path and longest path.
   c. All contractual milestones and their predecessor chains.
   d. All chains of activities alleged by the respondent to have constituted critical claimant-caused delays or concurrent delays due to specific fault of the claimant.
   e. All delays for which contract time extensions were granted.

5. The collapsing process should not involve any adjustment to logic, including lag values, or removal of constraints unless each instance of such adjustment is specifically tabulated and the basis of such adjustment explained.

6. Perform a constructability analysis of the resulting collapsed as-built schedules.

7. Reconcile all contract time extensions granted.

F. Enhanced Implementation Protocols

1. Reconcile the as-built and the collapsed as-built to the as-planned schedule.

2. Use all schedule activities found in the baseline schedule.

3. To account for periods during which work could not have progressed under the collapsed scenario, use a calendar simulating actual weather conditions.

4. Perform the analysis by modeling all schedule updates.

5. For each time period, create two models, one using hindsight progress rules, and the other using blind sight progress rules in modeling activities that were partially complete on the data date.

G. Identification of Critical and Near-Critical Paths for Each Periodic Update

Prior to the extraction of delays, pure computation of the criticality of a schedule activity under the collapsed as-built method is neither practical nor necessary. To fully verify the quantum of compensable delays, and to fully account for non-compensable concurrancies, the analyst must consider and extract the delays and then assess the criticality of the delay. This analogous critical path is used to identify the controlling activities of the collapsed as-built. See Subsection 3.9.K.5

Identification of the near-controlling path at this stage is not necessary if the significant set of as-built activities were properly selected when the as-built model was prepared.

The checklist for the identification of critical and near-critical paths is as follows:
• Identify and understand all related contractual language.
• Identify the negative float theory used by the opposing party.
• Identify and understand the implications of the choice of method, hindsight or blindsight, when modeling remaining durations of partially complete activities. (See Subsection 4.2.D.6)
• If necessary, identify the as-built controlling path(s) using Subsection 4.3.C.
• After extraction of delays, identify the analogous critical path (ACP). (See Subsection 3.9.K.5)

H. Identification and Quantification of Concurrent Delays and Pacing

As with MIP 3.8, even in its minimum implementation, concurrency analysis is built into MIP 3.9. Since the as-built, by definition, contains all delays that occurred on the activity paths modeled, to the extent that a subset of those delays are extracted, the post-extraction schedule still contains the impact of those delays that were left in the model, thereby accounting for the concurrent impact of those delays. Because of this, often the evaluation of pacing delays is a part of the extraction process. To what extent concurrent delays are evaluated is directly related to the significant set of activities that were integrated into the as-built model. However, the analyst must be aware that unlike MIP 3.8, this method contains a retrospective and a prospective portion within the logic-driven portion of each model. (See Figure 10).

The checklist for the identification of critical and near-critical paths is as follows:
• Determine whether compensable delay by contractor or owner is at issue.
• Identify and understand all related contractual language.
• For each delay event, distinguish the cause from the effect of delay.
• Determine whether literal or functional concurrency theory is to be used (see Subsection 4.2.).
• In a stepped extraction implementation, begin extraction with the delay event that is latest in time in the period being analyzed.
• Reconcile the total net variance between the as-built and the collapsed schedule by identifying the analogous critical path. (See Subsection 3.9.K.5)
• For each suspected pacing delay event, identify the parent delay(s) and establish the order of precedence between the parent delay and the pacing delay.
• For each suspected pacing delay event, evaluate whether enough resources could have been realistically employed to perform the paced activity within its original planned duration.

I. Determination and Quantification of Excusable and Compensable Delay

Identify and understand all contractual language related to delay apportionment and determine whether the contractual language would override any determination of excusability and compensability based on findings resulting from analyses performed under this RP.

Absent such overriding language, use the following procedure.
1. **Excusable and Compensable Delay (ECD)**

The difference between the as-built completion date and the collapsed as-built completion date resulting from the extraction of all owner-caused delays is the total ECD for each modeled time period. If the owner has paid the contractor specifically to accelerate, then any negative delay durations (delay mitigation) resulting from the owner-paid acceleration should be credited to the owner against the total ECD to avoid double payment to the contractor for acceleration. Where the quantification of the duration of the specific paid mitigation is not reasonably feasible, the credit adjustment may be accomplished by crediting the monetary value of the acceleration payment against the monetary value of the ECD.

2. **Non-Excusable and Non-Compensable Delay (NND)**

The difference between the as-built completion date and the collapsed as-built completion date resulting from the extraction of all contractor-caused delays is the total NND for each modeled time period. If the contractor accelerated or implemented other mitigating measures and the owner did not reimburse the contractor for the cost of mitigation, the net critical mitigation duration should be subtracted from the total NND.

3. **Excusable and Non-Compensable Delay (END)**

Because entitlement to END does not require that concurrency periods be eliminated, this method is too rigorous for quantifying END since it automatically accounts for concurrency. However, it can be said that the difference between the as-built completion date and the collapsed as-built completion date resulting from the extraction of all owner-caused delays is at least the total END for each modeled time period.

**J. Identification and Quantification of Mitigation / Constructive Acceleration**

The subtractive modeling methods are not the best tools for identifying and quantifying specific instances of acceleration and delay mitigation, since the methods start with the as-built schedule that already incorporates all acceleration measures to the extent that they were actually implemented. When the delays are subtracted, the resulting schedule still retains all acceleration measures that were built into the as-built. Therefore, the resulting comparison is that of one accelerated schedule to another, albeit one without delays.

However, the subtractive modeling methods are one of the only tools to identify and quantify the overall extent to which the contractor’s actual performance would have resulted in a project duration shorter than the baseline schedule, but for the delays. If the completion date of the collapsed update is earlier than that of the schedule update of the previous period, it can be claimed by the contractor that if allowed to proceed unhindered by delays, it was possible to finish earlier than originally planned. Whether the contractor would have decided to actually incur the necessary expenses to implement the acceleration measures absent delays must be proven independently of the schedule analysis.

**K. Specific Implementation Procedures and Enhancements**

1. **Choice of Analysis Periods**

   a. **Fixed Periods**

   The analysis periods are of virtually identical duration and may coincide with regular schedule update periods.

   b. **Variable Periods**
The analysis periods are of varying duration and are characterized by their different natures such as the type of work being performed, the types of delaying influences, or the operative contractual schedule under which the work was being performed.

c. Fixed Periods vs. Variable Periods

Similar to the comparison between the all-periods implementation and the grouped-periods implementation for MIP 3.3, 3.4, and 3.5, a frequent-fixed-periods implementation yields more information than the infrequent-variable-periods implementation and is considered more precise.

2. Order of Analysis Periods

a. The extraction process may be started by the sequence of time periods, working from the first period to the last, or from the last period to the first. Neither approach is necessarily better than the other since each period is reconciled with the contemporaneous schedule updates. However, when an activity and any delay to that activity occurs over more than one period of time, and the analyst does not know exactly during which period the delay occurred, and the delay could have occurred in either or both periods, the overall delay result for the project may vary based on the approach to choosing the period. The analyst should develop a consistent convention, such as choosing the first period in which the delay could have occurred to extract the delay.

3. Choice of Modeling Increments

a. Periodic Modeling

In periodic modeling, the logic-driven as-built schedule occupies the period starting with the day after the data date of the previous update and ending with the data date of the current update from which the as-built model is generated. The data date of the previous update remains the data date for the model. This data date will be referred to as the hard data date of the model in order to distinguish it from the soft data date which is the data date of the current update from which the model was generated. The soft data date is so named because the calculation discontinuity of the data date of the source update is blurred or softened in the continuous CPM logic spanning the source update data date, as shown in the diagram below.
Hindsight progress rules are used to model the as-built at the hard data date of the model, since this point in time is already fully progressed in the source update. The analyst has a choice of rules, hindsight or blindsight, in modeling the as-built at the soft data date since on one hand, this point in time is the hard data date of the source update, but on the other hand, if the analysis is being performed after project completion, full as-built information is available. The difference in progress rules used for modeling may make a difference in the calculation of the critical path(s), near-critical paths, longest path(s), and the near-longest paths.

b. Cumulative Modeling

In a cumulatively modeled set of MIP 3.9 as-builds, the hard data date is set for the first model, and all subsequent models use the same hard data date. In many cases the initial hard data date is the same as that of the baseline schedule. The soft data date of the models moves with the data date of the source updates. If the final source update is a fully progressed update, the final as-built model will be identical to a MIP 3.8 model based on a fully progressed update, as shown in the diagram below.
As with the periodic modeled set of as-builds, the analyst has a choice of rules, hindsight or blindsight, in modeling the as-built at the soft data date since on one hand, this point in time is the hard data date of the source update, but on the other hand, if the analysis is being performed after project completion, full as-built information is available. The difference in progress rules used for modeling may make a difference in the calculation of the critical path(s), near-critical paths, longest path(s), and the near-longest paths.

4. **Choice of Extraction Modes**

   a. **Global Extraction**

      All the delay events and influences in each model are extracted together and the impact is determined on the combined effect of the extracted delays.

   b. **Stepped Extraction**

      The delays are extracted individually or in groups, and the impact is determined after each iterative extraction. Stepped extraction should be in reverse chronological order of the occurrence of the delay event. This is the opposite of the order recommended for the additive MIP’s, 3.6 and 3.7. In the additive methods, the base schedule contains no delays, so it makes sense to start the additive process chronologically. In MIP 3.9, the base schedules already contain all the delays. If extraction is performed chronologically, the iterative results would make no sense. For example, extracting the earliest delay first would create a schedule that still contains...
5. Creating a Collapsible As-Built CPM Schedule

The procedure for creating a collapsible as-built schedule for each period analysis is the same as presented in Subsection 3.8.K.2, except that the process must be repeated for the relevant analysis period for each as-built schedule update.

6. Identification of the Analogous Critical Path (ACP)

The procedure for identifying the Analogous Critical Path for each period analysis is the same as presented in Subsection 3.8.K.3, except that the process must be repeated for the relevant analysis period for each as-built schedule update.

L. Summary of Considerations in Using the Minimum Protocol

- Accounts for changes in the prospective critical path for each schedule update utilized.
- Concept is intuitively easy to understand and present.
- Can isolate owner and/or contractor-caused delays if there is sufficient detail in the as-built schedule.
- Relies upon history of actual events.
- This method requires a baseline schedule and subsequent schedule updates in addition to the as-built schedule.
- Relatively few practitioners with significant, hands-on experience in properly performing this method.

M. Caveats in Using the Minimum Protocol / Conditions Requiring Enhanced Protocols

- Summarized as-built variation of the minimum protocol creates the potential for missing scope of work or the skewing of results of the analysis.
- Reconstructing the as-built schedule is very fact and labor intensive.
- Assignment of logic to mimic as-built conditions requires subjective decisions that sometimes do not match the contemporaneously planned logic relationships between activities.
- Susceptible to unintended or intended manipulation during as-built logic assignments.
- Not suited for identification or quantification of acceleration because the source as-built schedule already incorporates acceleration.
- More time-consuming and hence more expensive to implement than other MIP’s.

4. ANALYSIS EVALUATION

4.1 Excusability and Compensability of Delay
4.2 Identification and Quantification of Concurrency of Delay
4.3 Critical Path and Float
4.4 Delay Mitigation & Constructive Acceleration

The ultimate conclusion sought in forensic schedule analysis involving delay disputes is the determination and quantification of excusable delays along with the compensability of such delays. The analysis methods outlined in Section 3 are the tools used in reaching this ultimate conclusion. This section describes the procedures for interpreting the results obtained from the use of the methods described in Section 3.

The process of segregating non-excusable, excusable, and compensable delays is referred to herein as *apportionment* of the responsibility for delay. Many jurisdictions in the United States and other countries prefer the use of critical path method (CPM) techniques for the purpose of apportionment of delay. This is in distinction to the use of other techniques such as bar-charts without network logic or by gross allocation of fault by percentage, often called the pie-chart method.

Subsection 4.1 was placed first so that the reader can gain an overview before delving into the underlying technical concepts. The analyst must be familiar with the concepts of concurrency of delay (Subsection 4.2), and criticality and float (Subsection 4.3) in order to fully understand the concepts in the first Subsection, 4.1. Therefore, for issues involving delay, the actual order of performance of the analysis interpretation protocol would be Subsection 4.3 first, then 4.2 followed by 4.1.

Constructive acceleration, along with recovery schedules, disruption, and delay mitigation are addressed in Subsection 4.4. Even if the project did not result in actual slippage of the completion date, these issues still generate disputes. Because the issues are intertwined with excusability of delay, they are discussed here in Section 4.

Be advised that differences in analysis methods combined with differences in concurrency and float theories may result in conflicting ultimate conclusions. The primary purpose of this section is to describe and explain the different theories in order to aid in the reconciliation of the conflicting conclusions.

4.1. Excusability and Compensability of Delay

A. General Rules

*Excusability* exists where there is contractual or equitable justification in a claimant’s request for a contract time extension for relief from potential claims for liquidated/stipulated or actual delay damages. The showing of excusability does not necessarily mean that the claimant is also entitled to compensation for the delay. Conversely, delay is *non-excusable* when such justification does not exist.

*Compensability* or *compensable delay* exists where the claimant is entitled to recover not only a time extension but compensation for expenses associated with the extension of completion date or the prolongation of the duration of work. Excusability is a prerequisite to compensability. Therefore, where compensability can be established, excusability is assumed.

B. Accounting for Concurrent Delay

In the absence of any contractual language or other agreements, the conventional rule governing

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8 As a practical matter, delay analysis is just an intermediate step towards the ultimate question of financial liability. Thus, if agreement can be reached directly on the question of the specific amount of financial liability, the forensic schedule analysis leading to an apportionment of delay liability is moot.
9 The contracting parties are free to depart from the general rule by mutual agreement as long as such agreement does not violate public policy.
compensability is that the claimant must first account for concurrent delays (see Subsection 4.2) in quantifying the delay duration to which compensation applies. That is, the contractor is barred from recovering delay damages to the extent that concurrent contractor-caused delays offset owner-caused delays, and the owner is barred from recovery liquidated/stipulated or actual delay damages to the extent that concurrent owner-caused delays offset contractor-caused delays.

The evaluation proceeds in two distinct steps. First, the liability for each delay event is individually analyzed\textsuperscript{10}. The classification is made primarily according to the responsibility for the cause of the delay but may also consider the contractual risk allocation of the delay event regardless of the party who caused such delay. The second step consists of evaluating whether each delay event is concurrent with other types of delays to arrive at the final conclusion of excusability, compensability, or non-excusable.

As evident from the list of existing definitions, the current, common usage of the terms compensable, excusable, and non-excusable is confusing because analysts often use those terms to characterize the assignment of liability performed in the first step. For the purpose of this RP, the delays identified in the first step will be classified as: contractor delay, owner delay, or force majeure delay.

A contractor delay is any delay event caused by the contractor or the risk of which has been assigned solely to the contractor\textsuperscript{11}. If the contractor delay is on the critical path, in the absence of other types of concurrent delays, the contractor is granted neither an extension of contract time nor additional compensation for delay related damages. Such a delay may expose the contractor to a claim for damages from the owner.

An owner delay is any delay event caused by the owner, or the risk of which has been assigned solely to the owner\textsuperscript{12}. If the owner delay is on the critical path, in the absence of other types of concurrent delays, the contractor is granted both an extension of contract time and additional compensation for delay related damages.

A force majeure delay is any delay event caused by something or someone other than the owner (including its agents), or the contractor (or its agents), or the risk of which has not been assigned solely to the owner or the contractor. If the force majeure delay is on the critical path, the contractor is granted an extension of contract time but does not receive additional compensation for delay related damages even if there is a concurrent delay.

After liability is determined in the first step, the second step requires a determination of concurrency in accordance with Subsection 4.2. The various permutations of concurrency scenarios are summarized below in Figure 12 – Net Effect Matrix.

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\textsuperscript{10} Note that the forensic scheduling analyst may not possess the skill, knowledge, or experience to independently determine the legal liability for an event. In such a case, the first step consists of making a reasoned assumption of liability subject to verification by those with the requisite expertise.

\textsuperscript{11} The SCL Delay & Disruption Protocol calls this a contractor risk event which is defined as an event or cause of delay which under the contract is at the risk and responsibility of the contractor. SCL also calls it a non-compensable event.[1]

\textsuperscript{12} The SCL Delay & Disruption Protocol calls this an employer risk event which is defined as an event or cause of delay which under the contract is at the risk and responsibility of the employer (owner). SCL also calls it a compensable event.[1]
<table>
<thead>
<tr>
<th>Delay Event</th>
<th>Concurrent with</th>
<th>Net Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owner Delay</td>
<td>Another Owner Delay or Nothing</td>
<td>Compensable to Contractor, Non-Excusable to Owner</td>
</tr>
<tr>
<td>Owner Delay</td>
<td>Contractor Delay</td>
<td>Excusable but Not Compensable to both Parties</td>
</tr>
<tr>
<td>Owner Delay</td>
<td>Force Majeure Delay</td>
<td>Excusable but Not Compensable to both Parties</td>
</tr>
<tr>
<td>Contractor Delay</td>
<td>Another Contractor Delay or Nothing</td>
<td>Non-Excusable to Contractor, Compensable to Owner</td>
</tr>
<tr>
<td>Contractor Delay</td>
<td>Force Majeure Delay</td>
<td>Excusable but Not Compensable to both Parties</td>
</tr>
<tr>
<td>Force Majeure Delay</td>
<td>Another Force Majeure Delay or Nothing</td>
<td>Excusable but Not Compensable to Contractor</td>
</tr>
</tbody>
</table>

Figure 12 – Net Affect Matrix – Concurrent Delay

There are two alternatives if there are more than two parties among which the delay must be apportioned depending on whether the additional parties are distinct signatories to the subject contract or whether the parties are agents and therefore subsumed under the two primary parties.

Under the first alternative there would be another factor added to the above matrix. But, the principle used to derive the net effect would be the same. Namely, in order to be entitled to compensation the party must not have caused or otherwise be held accountable for any concurrent delay and concurrent *force majeure* delays.

Under the second alternative involving agents to the two primary parties such as subcontractors, suppliers, architects, and construction management firms, the net effect equation should be solved first between the two primary parties. This is followed by a subsidiary analysis apportioning the quantified delay allocation established by the first analysis.

C. Equitable Symmetry of the Concept

Note that the terms compensable, excusable, and non-excusable in current industry usage are from the viewpoint of the contractor. That is, a delay that is deemed compensable is compensable to the contractor but non-excusable to the owner. Conversely, a non-excusable delay is a compensable delay to the owner since it results in the collection of liquidated/stipulated damages.

A neutral perspective on the usage of the terms often aids understanding of the parity and symmetry of the concepts. Thus entitlement to compensability, whether it applies to the contractor or the owner, requires that the party seeking compensation shows a lack of concurrency if concurrency is alleged by the other party. But for entitlement to excusability without compensation, whether it applies to the contractor or the owner, it only requires that the party seeking excusability show that a delay by the other party impacted the critical path.

Based on this symmetry, contractor entitlement to a time extension does not automatically entitle the contractor to delay compensation. The contractor would first have to show that an owner delay impacted the critical path, and then if the owner defends alleging concurrent delay, the contractor would have to show the absence of concurrent delays caused by a contractor delay or a *force majeure* delay in order to be entitled to compensation.

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11 Especially in the absence of contractual provisions to the contrary. For example, depending on the contract language and applicable law, the applicable tests for the recovery of actual delay damages may be different from that applicable to the owner’s right to liquidated/stipulated damages.
A contractor delay concurrent with many owner delays would negate the contractor’s entitlement to delay compensation. Similarly, one owner delay concurrent with many contractor delays would negate the owner’s entitlement to delay compensation, including liquidated/stipulated damages. While in such extreme cases the rule seems draconian, it is a symmetrical rule that applies to both the owner and the contractor and hence ultimately equitable.

### 4.2. Identification and Quantification of Concurrent Delay

**A. Relevance and Application**

Projects are frequently delayed by multiple impacts and by multiple parties. The concept of concurrent delay is based upon the premise that when multiple parties independently contribute to an impact to the critical path, the party or parties causing the event should be responsible for their share of that project critical path impact. There can be concurrent delays between separate delay events both caused by the same party. However, in such case there is effectively no need for a concurrency analysis. Throughout this Recommended Practice, it has been assumed that concurrency exists only when it is caused by at least two separate parties or between at least one party and a force majeure event. While the allocation and distribution of concurrent delay impacts should always be based upon the terms and conditions of the contract, most contracts are silent on the subject of concurrent delay. This section is intended to identify and facilitate the calculation and apportionment of concurrent delay impacts.

Typically, Owners assess liquidated/stipulated damages for non-excusable delay and Contractors claim entitlement to extended overhead reimbursement for compensable delay. In each case, the damages are typically calculated on the basis of a daily unit rate. Under most concurrent delay applications however, the Owner and Contractor time-related damages are not offset against each other when concurrent delay can be demonstrated. Typically, when both Contractor and Owner are concurrently responsible for an extended period of performance, the Contractor is granted an extension of contract time without compensation and the Owner forgoes the collection of liquidated/stipulated damages. No time-related compensation flows from either party to the other. Generally, therefore, substantial incentive exists for:

1. The Contractor to demonstrate concurrent excusable delay during a period likely to be considered non-excusable delay; and
2. The Owner to demonstrate concurrent non-excusable delay during a period likely to be considered excusable delay.

Accordingly, both Owners and Contractors frequently contend that concurrent delays offset each other as a defense to excuse their potential liability to compensate the other party for time related costs.

The identification and quantification of concurrent delay is arguably the most contentious technical subject in forensic schedule analysis. Accordingly, it is important that all sides, if possible, agree on either the Literal or Functional theory (See Subsection 4.2.D.1.) employed in the identification and quantification of concurrent delay. Failing that, the analyst should be aware of the theory adopted by the opposing party.

**B. Various Definitions of Concurrency**

AACE Recommended Practice No. 10S-90 Cost Engineering Terminology, lists five different but similar definitions for concurrent delay.\[4\] As discussed more fully in the sections that follow, the five definitions reflect some of the differing opinions and applications associated with concurrent delay. The apparent contradictions underscore why this has become one of the most contentious areas of forensic schedule delay analysis.
(1) Two or more delays that take place or overlap during the same period, either of which occurring alone would have affected the ultimate completion date. In practice, it can be difficult to apportion damages when the concurrent delays are due to the owner and contractor respectively.

(2) Concurrent delays occur when there are two or more independent causes of delay during the same time period. The “same” time period from which concurrency is measured, however, is not always literally within the exact period of time. For delays to be considered concurrent, most courts do not require that the period of concurrent delay precisely match. The period of “concurrency” of the delays can be related by circumstances, even though the circumstances may not have occurred during exactly the same time period.

(3) True concurrent delay is the occurrence of two or more delay events at the same time, one an employer risk event, the other a contractor risk event and the effects of which are felt at the same time. The term ‘concurrent delay’ is often used to describe the situation where two or more delay events arise at different times, but the effects of them are felt (in whole or in part) at the same time. To avoid confusion, this is more correctly termed the ‘concurrent effect’ of sequential delay events.

(4) Concurrent delay occurs when both the owner and contractor delay the project or when either party delays the project during an excusable but non-compensable delay (e.g., abnormal weather). The delays need not occur simultaneously but can be on two parallel critical path chains.

(5) The condition where another delay-activity independent of the subject delay is affecting the ultimate completion of the chain of activities.

The existence of a contractual definition is a major factor on the determination of concurrency. As stated in the previous subsections, contracting parties are free to mutually agree on any method or procedure as long as those agreements are legally enforceable. Therefore, the general rules, exceptions, and considerations in this RP are applicable to the extent that they do not directly contradict contractual definitions and specifications.

C. Pre-Requisite Findings Concerning the Delays Being Evaluated for Concurrency

Before evaluation of concurrency, there must be:

- Two or more delays that are unrelated, independent, and would have delayed the project even if the other delay did not exist;
- Two or more delays that are the contractual responsibility of different parties, but one may be a force majeure event;
- The delay must be involuntary; and,
- The delayed work must be substantial and not easily curable.

1. Two or More Delays that are Unrelated and Independent

Concurrent delays occur when two or more unrelated and independent events delay the project. When two or more parties contribute to a single delay to the project and the causation is linked or related, the event is not considered to have two concurrent causes. The distinction between concurrent delay and mutually-caused delay is a subtle, yet a vitally important distinction that each analyst must observe and reconcile.

There must be at least two independent delay events. The first event, for example, could be the Owner’s failure to timely approve the purchase of a piece of Owner-furnished equipment. The second and potentially concurrent event could be the Contractor’s failure to advance steel erection sufficiently to support the installation of that equipment. These two independent events are often separate, co-critical network paths,
but they need not be in order to be candidates for a concurrent delay. The delay events could affect the same activity, but must be independent.

Care must be taken to ensure the events are truly independent. In the example above, the facts might show that the steel was not erected timely because the Contractor knew the equipment was going to be late. In such a case, the “two” delay events are actually one – they are both caused by the Owner’s failure to timely approve the purchase of a piece of equipment.

2. Two or More Delays that are the Contractual Responsibility of Different Parties

The application of concurrent delay theory is only relevant when the delays are the responsibility of different parties or one of the delays is a force majeure event. Since the concept of concurrency has both a legal and a technical component, the concurrent events must contractually be the responsibility of separate parties. The parties are typically the Owner and the Contractor. Some contracts contain language assigning responsibility or contractual risk for certain types of events such as differing site conditions and force majeure events. Such risk assignment may impact the liability of events causing concurrent delay.

If one of the delay events is contractually assigned to neither or both parties, such as a force majeure event, the effective result is the same as concurrency; it is excusable and non-compensable to either party. Generally, whenever a force majeure event occurs, it trumps any other concurrent delay that might have occurred. This serves two purposes: first, it can eliminate or reduce significant proof problems that might arise in establishing responsibility, and second, it promotes equity, since one of the delays is beyond the control and responsibility of the either of the parties.

3. The Delay Must Be Involuntary

A delay that otherwise meets the requirements of concurrency, but is performed voluntarily is generally considered pacing. If the delay could have been easily cured, but was not, the delay would be considered voluntary. See Subsections 4.2 E and F below.

4. The Delay Must Be Substantial and Not Easily Curable

This requirement comports with common sense. If one of the delays is associated with a minor element of work that could easily be performed, that work should not create a concurrent delay. This element is closely allied with the involuntary nature of truly concurrent delays cited above.

D. Functional Requirements Establishing Concurrency and the Factors that Influence Findings

Having satisfied the four requirements on the nature of the subject delay events being evaluated for concurrency, there are two major functional requirements relating to the relationship of the delays.

- The delays must occur during or impact the same time analysis period.
- The delays, each of which, absent the other, must independently delay the critical path.

The first functional requirement that the delays must occur during or impact the same analysis time period is intuitively obvious, but difficult to absolutely satisfy. This is due to the fact that absolute, literal concurrency is an unachievable goal since time is infinitely divisible. It is more a function of the planning unit used by the schedule or the verification unit used in the review of the as-built data. For example, upon further examination, a pair of events that were determined to have occurred concurrently on a given day may not be literally concurrent because one occurred in the morning and the other in the afternoon. This condition seldom occurs since most construction schedules use the day as the smallest measurement of time.
The second functional requirement is that each concurrent delay event must, absent the other, delay the timely completion of a completion milestone. Such independent events must also be on the critical path or near critical path, depending on the time analysis period and the concurrency theory being used. For example, assume that a forensic analysis confirms that the late installation of drywall caused a critical path delay to the completion of the project. This work was critical to the commencement of final painting and interior trim work. Further assume that the delay in the drywall was the result of two factors: first, the general contractor failed to procure its drywall subcontractor in a timely manner and second, there was a severe shortage of drywall to the region. These events are unrelated, but either one of them would have delayed the overall completion of the drywall. This test is sometimes called the “but-for” test. But-For the failure to procure the drywall subcontractor, the work would still have been late because of the shortage of materials.

Findings of concurrency analysis to determine compliance with these functional requirements are highly dependent on several factors, all of which are dictated by discretionary choices made by the analyst in the course of analysis – these choices should be well documented as part of the analysis. There are at least six factors, each discussed in detail below, that influence the determination of these two conditions:

- Whether concurrency is determined literally or functionally
- Whether criticality is determined on least-value float or less-than-one float value
- Whether concurrency is determined on the cause or the effect of delay
- The frequency, duration and placement of the analysis interval
- The order of delay insertion or extraction in a stepped implementation
- Whether the analysis is done using full hindsight or blindsight (knowledge-at-the-time).

There is no consensus on the many factors that affect the identification and quantification of concurrency. The one thing that seems to be universally accepted is that reliable identification and quantification of concurrency must be based on CPM concepts, particularly distinguishing critical from non-critical delays. Gross concurrency, or the method of counting concurrent delay events based purely on contemporaneous occurrence without regard to CPM principles, is typically not a sufficient basis for concluding that a delay is not compensable.

1. **Literal Concurrency vs. Functional Concurrency**

   There are two different theories regarding the exact timing of the two or more delays that are candidates for concurrency. Under the Literal Theory, the delays have to be literally concurrent in time, as in “happening at the same time.” In contrast, under the Functional Theory, the delays need to be occurring within the same analysis period.

   Of the two, the functional theory is more liberal in identifying and quantifying concurrency since the delays need only occur within the same measurement period, while in the literal theory, only delays require same-time occurrence. The assumption made by the functional theory practitioner is that most delays have the potential of becoming critical, once float on the path on which they resides has been consumed.

   An advocate of functional concurrency believes that if the two delays occur within the same measurement period [usually a month] they can be concurrent. For example, analyses that are based upon monthly update submissions will manifest delay only at the end of the month. It is quite possible therefore, that an Owner-caused delay occurring in the first week of the update period may appear concurrent with a Contractor-caused delay occurring in the last week of the update period. These delay events could nonetheless be concurrent so long as the other tests are met. Accordingly, the functional application of concurrent delay theory does not necessarily require the delay events to occur on the same days.

   This type of functional concurrency is closely attuned to delay methodologies that use modeled CPM
schedules as their basis and utilize some form of time period analysis. Since these analyses measure delay at the end of time periods [typically the status updates] it makes sense to measure concurrency under this methodology at the same points, rather than trying to develop a separate concurrency analysis. Accordingly, the functional application of concurrent delay theory does not necessarily require the delay events to occur at the same time. In addition, the functional theory allows that CPM schedules, even if properly maintained, are not perfect, and near critical delays may in fact be concurrent.

The literal theory will result in the identification of fewer concurrent delays, since delays are dropped from the list of suspects if they do not share real-time concurrency. Since the literal theory is based on the general notion that concurrent delays must be on the critical path and occur at the same time (usually measured at a day interval), findings of concurrency are exceedingly rare.

An advocate of literal concurrency prefers to view concurrency in the context of day-to-day performance. Under this theory, if the first delay started on day one, and the second delay started on day two, they would not be concurrent – the delay associated with the first event would create float in the entire project so the second delay could not also be on the co-critical path. In the case where two independent delay events act on the same activity, the same rational applies: the first delay event causes the delay, while the second does not. Literal concurrency generally identifies fewer concurrent delays than functional concurrency. Since literal concurrency requires the delay events to occur at the same time and functional concurrency only requires that the events occur within the same measurement period, it is very likely that more concurrency will be recognized under the functional theory. The literal theory requires the forensic analyst to look inside a monthly update. In one sense, this approach vitiates the analysis of monthly progress because the status depicted at the end of the month is insufficient.

The difference in outcome between the literal and functional theory is significant. Given the same network model, the literal theory practitioner will find less concurrency -- many more compensable delays for both parties. The functional theory practitioner will find many of those delays to be concurrent and hence excusable but, depending on the terms of the contract, non-compensable for both parties. It is also possible that the ultimate outcome may be similar when, under the literal theory, the compensation due one party is cancelled by the compensation due the other party. The only significant difference, despite the fact that the canceling effect (functional) operates under both theories, is the timing of the canceling effect and its impact on the damage calculation (literal).

Under the literal theory, an owner delay and a contractor delay of equal duration, occurring at different times are calculated as a period of compensable delay for the owner and a separate period of compensable delay of equal length for the contractor. The two periods will neither cancel each other out in time, nor money, since the contractor is likely to get a time extension for the owners delay and it is unlikely the owner’s liquidated/stipulated damages rate will not be equal to the contractor’s extended project rate. So, despite the apparent canceling effect, there is still potential of award of compensability to one side or the other. In contrast, under the functional theory, the canceling effect is realized before calculation of damages; hence there will be no offsetting calculation for damages.

The functional theory also recognizes the real-world limitations of exactly measuring delays and limitations of scheduling accuracy. While CPM schedules measure activities and events to the day, it is often difficult to retrospectively identify, with the exactitude of a day, the events on a project. By measuring possible concurrent delays with a measurement period larger than a day, the functional theory accommodates this real-world limitation. At the same time as the measurement period expands, it is likely that more delays will get treated like concurrent delays.

When evaluating the relevance of the time period, it is important to consider whether the concurrency analysis is being performed contemporaneously or forensically. Concurrent Delay analysis is frequently applied
on projects that are still under construction because the full scope of the impact may not yet be known. Both parties to a construction contract often recognize that a full and final settlement of delay on a contemporaneous basis is not only compliant with the terms of the contract, but it provides a means to effectively balance risk on delays that are not yet complete. Contemporaneous analyses therefore, are often more functional than they are literal. When delay analyses are performed forensically, however, the standard-of-care increases because the settlement is likely to be based on technical proof rather than mid-project business decisions. Accordingly, forensic concurrency analyses are more likely to be literal in nature.

2. Least Float vs. Negative Float

The use of Negative Float or Longest Path Theory (Subsection 4.3.A.2.) for identification of critical activities can have a profound effect on the calculation of concurrent delay. The disparity stems from divergent approaches to criticality. Virtually all forensic delay methodologies provide for extensions of contract time on the critical path only. Therefore, the definition of the critical path is of utmost importance.

The Negative Float Theory assumes criticality on any activity that has negative total float relative to a contractual milestone. There is a certain practicality to this approach since most parties working from a CPM schedule will generally move to advance any activities that have negative total float because they are all essential to the maintenance or recovery of project delay.

The Longest Path Theory provides for criticality on the longest path only, even if other secondary paths are late with regard to a contractual milestone. Under the Longest Path Theory, all paths shorter than the longest path (even those with negative total float) have positive total float with respect to the longest path and are therefore not critical. In contrast, under the Negative Float Theory, any delays, occasioned by negative total float, occurring during the same measurement period are potential candidates for concurrency.

Concurrency analyses should always be consistent with the contract’s definition of criticality. While it is beyond the scope of this document to catalogue the variations in contractual specifications, one relatively common definition is worth mentioning. Namely, some contracts include in the definition of concurrent delay that it cause a critical path delay. The requirement that the concurrent delay be critical, in effect, excludes other delay events with float values greater than the critical path from being evaluated for offsets against compensable delays. This view comports with the Literal Theory. It can be argued that absent such contract definition, non-critical delays can be used to offset compensable delay on a day-for-day basis after the expenditure of relative float against the critical path. This view comports with the Functional Theory.

3. Cause of Delay vs. Effect of Delay

Another philosophical dichotomy that complicates the evaluation of concurrency is the difference between the proximate (immediate) cause of the delay and effect of the delay.

For example, assume a schedule activity with a planned duration of five days experiences work suspensions on the second day and the fifth day, thereby extending the duration by two days. The delaying events are on the second and the fifth day, but the delay-effect is on the sixth and the seventh day. The differences become much larger on activities with longer planned durations that experience extended delays. A good example would be delayed approval of a submittal that stretches for weeks and months.

The philosophical difference rests on the observation by the delay-effect adherents that there is no ‘delay’ until the planned duration has been exhausted. In contrast, the delay-cause adherents maintain that the identification of delay should be independent of planned or allowed duration, and instead should be driven by the nature of the event. The disadvantage of the delay-cause theory is that if there are no discrete events that cause a schedule activity to exceed its planned duration, it would have to fall back to the delay-effect method
of identifying the delay. Conversely, in cases where the delay was a result of a series of discrete events, the delay-effect method of chronological placement of delay would often be at odds with contemporaneous documentation of such discrete events.

The difference in outcome is pronounced under the literal theory, since it affects whether or not a delay is identified as concurrent. Under the functional theory the significance to the outcome depends on whether the analyst is using a static method (MIP 3.1, 3.6 or 3.8) or a dynamic method (MIP 3.2, 3.3, 3.4, 3.5, 3.7 or 3.9). Using a static method, the cause-effect dichotomy makes no difference because the entire project is one networked continuum. But using a dynamic method, it does make a difference because the chronological difference between the cause and effect may determine the analysis interval in which the delay is analyzed.

There are two solutions to reconcile this potential dichotomy between the static and dynamic methods. One solution is to use the cause theory where discrete delay events are identifiable and to use the effect theory where there are no identifiable discrete events that led to the delay. But note that in many cases the identification of discrete causes is a function of diligence in factual research, which is in turn dictated by time and budget allowed for the analysis. The second solution is to review the delay on an activity basis and not to review the events on a daily basis within the event. This solution comports with the reality that delays that occur at the outset of an activity may be made up during the performance of that activity.

4. Frequency, Duration, and Placement of Analysis Intervals

Analysis interval refers to the individual time periods used in analyzing the schedule under the various dynamic methods (MIP 3.2, 3.3, 3.4, 3.5, 3.7 and 3.9). The frequency, duration and the placement of the analysis intervals are significant technical factors that influence the determination of concurrency. The significance of the analysis interval concept is also underscored by the fact that it creates the distinction in the taxonomy between the static versus the dynamic methods. The static method (MIP 3.1, 3.6, or 3.8) has just one analysis interval, namely the entire project, whereas the dynamic model segments the project into multiple analysis intervals.

a. Frequency and Duration

Concurrency is evaluated discretely for each analysis interval. That is, at the end of each period, accounting of concurrency is closed, and a new one opened for the next period. This is especially significant when analysis proceeds under the functional theory of concurrency in cases where two functionally concurrent delay events, one owner delay and the other a contractor delay, are separated into separate periods. If those delay events were contained in one period, they would be accounted together and offset each other. When they are separated, they would each become compensable to the owner and the contractor respectively. The analyst is recommended to analyze multiple-period events in both separate periods and combined periods to achieve the most accurate results.

However, the distinction between the functional and the literal theories does not disappear automatically with the use of multiple analysis intervals. Two delay events separated by time within one analysis interval will still be treated differently depending on which theory is used. The distinction becomes virtually irrelevant only when the duration of the analysis interval is reduced to a single day.

When multiple analysis intervals are used an additional dimension is added to the canceling effect that was discussed in the comparison of the literal theory to the functional theory. As stated above, the separation of two potential concurrent delay events into different analysis intervals causes the functional theory to behave like the literal theory. Because the change from one period to another closes analysis for that period and mandates the identification and quantification of excusable, compensable and non-excusables delays for that period, it is only after all the analysis intervals, covering the entire duration of
the project, are evaluated that reliable results can be obtained by performing a ‘grand total’ calculation. In other words, the ultimate conclusion cannot be reached by selective evaluation of some, but not all, analysis intervals.

b. Chronological Placement

The general rule that all the intervals be evaluated will ensure the reliability of the net result. But the analyst can still influence the characterization of the delays by determining the chronological placement of the boundaries of the intervals, or the cut-off dates.

There are two main ways that the analysis intervals are placed. The first method is to adopt the update periods used during the project by using the data dates of the updates, which are usually monthly or some other regular periods dictated by reporting or payment requirements. The other is the event-based method in which the cut-off dates are determined by key project events such as the attainment of a project milestone, occurrence of a major delay event, change in the project critical path based on progress (or lack thereof), or a major revision of the schedule. Event-based cut-off dates may not necessarily coincide with any update period.

The most distinguishing feature of the event-based placement of cut-off dates is that there is significant independent judgment exercised by the forensic analyst in choosing that time period. Because the cut-off date is equivalent to the data date used for CPM calculation, it heavily influences the determination of criticality and float, and hence the identification and quantification of concurrent delays. Also, as stated above, the placement of cut-off date plays a major role in how the canceling effect operates.

5. Order of Insertion or Extraction in Stepped Implementation

In a stepped insertion (MIP 3.6, and 3.7) or extraction (MIP 3.8, and 3.9) implementation, the order of the insertion or extraction of the delay may affect the identity of potentially concurrent delays and their quantification.

As a general rule, for additive modeling methods where results are obtained by the forward pass calculation, the order of insertion should be from the earliest in time to the latest in time. For subtractive modeling methods the order is reversed so that the stepped extraction starts with the latest delay event and proceeds in reverse chronological order.

There are other systems, such as inserting delays in the order that the change orders were processed, or extracting delays grouped by subcontractors responsible for the delays. In all these seemingly logical schemes if chronological order of the delay events is ignored, the resulting float calculation for each step may not yield the data necessary for reliable determination of concurrent delays.

6. Hindsight vs. Blindsight

The difference between the prospective and the retrospective modes was addressed in Section 1. In this section however, we are reviewing two ways to view historic events in retrospective analysis. The first is “hindsight,” where the analysis uses all the facts, regardless of the contemporaneous knowledge, in determining what occurred in the past. The second is “blindsight” where the analysis evaluates events as-if standing at the contemporaneous point in time, with no knowledge of subsequent events. This RP deals primarily with the retrospective mode of analysis. The determination of concurrency made prospectively during the project is usually done using the functional theory so as to resolve potential concurrences as they occur –essentially blindsight. However, such determinations may be discovered to be incorrect in hindsight using retrospective information. Thus, in the context of forensic schedule analysis, the analyst must be aware
of the difference when reconciling the results of the retrospective analysis utilizing full hindsight with findings made during the project when the future was unknown.

The one place where this difference becomes technically relevant in the practice of forensic schedule analysis is in rectifying and reconstructing schedule updates (MIP 3.5 and 3.9). Specifically, the assignment of remaining duration to each partially progressed activity is highly dependent on whether the approach is hindsight or blindsight. Because CPM calculation of schedule updates depends, in part, on the value of remaining duration of activities at the data date, the difference in approach may affect the identification and quantification of concurrent delays.

In the Figure below, Activity A has an original duration of 21 work days, starts several days after the first Monthly Status Update, and has been in progress 20 work days at the time of the second Monthly Status Update.

![Blindsight Method for Determining Remaining Durations of Activities in Progress](image)

**Figure 13 - Blindsight Method for Determining Remaining Durations of Activities in Progress**

Using the Blindsight method, and not knowing that any delay had occurred during the first 20 work days of progress, the remaining duration could be said to be only one work day at the time of the second Monthly Status Update. It would not be known until the activity was complete after the second Monthly Status Update that its as-built duration was 25 work days.

The next figure below illustrates the remaining duration of an activity using the hindsight method:
In this example, the same Activity A, which had an original duration of 21 work days, starts several days after the first Monthly Status Update, and based on the as-built data, finishes with an actual duration of 25 work days. The second Monthly Status Update occurs after 20 work days of progress on Activity A have occurred. Therefore, the analyst would conclude that the Activity A is 80 percent complete at the second Monthly Status Update, and would have a Remaining Duration of 5 work days at that time.

There is no prevailing practice, let alone agreement, on which practice ought to be used in the reconstruction of schedule updates. On one hand, the hindsight supporters maintain that it serves no purpose to ignore best available evidence and recreate updates, pretending that the as-built information does not exist. On the other hand, the blindsight supporters argue that the very purpose of reconstructing schedule updates is to replicate the state of mind of the project participants at the time of the update, because project decisions were made based on best available information at the time.

It is recommended that both approaches be evaluated in cases where difference in approach results in a significance variance.

**E. Defining the Net Effect of Concurrent Combinations of Delay**

If the contract documents are silent with regard to delay event definition, they are also likely to be silent on the net effect of concurrent combinations of delay. Under the foregoing delay definitions, there are just three potential combinations of discrete delay events. The following figure assumes the more common contractual situation where Force Majeure events are excusable but non-compensable events.

In the absence of specific contract language to the contrary, this Recommended Practice suggests the following protocol:
<table>
<thead>
<tr>
<th>Delay Event 1</th>
<th>Delay Event 2</th>
<th>Net Effect</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Force Majeure Delay</strong> [Time / No Compensation for Extended Overhead / No Liquidated/stipulated Damage Assessment]</td>
<td>concurrent with Contractor Caused Delay [No Time / No Compensation for Extended Overhead / Liquidated/stipulated Damage Assessment]</td>
<td><strong>Excusable</strong> [Time / No Compensation for Extended Overhead / No Liquidated/stipulated Damage Assessment]</td>
</tr>
<tr>
<td><strong>Force Majeure Delay</strong> [Time / No Compensation for Extended Overhead / No Liquidated/stipulated Damage Assessment]</td>
<td>concurrent with Owner Caused Delay [Time / Compensation for Extended Overhead]</td>
<td><strong>Excusable</strong> [Time / No Compensation for Extended Overhead / No Liquidated/stipulated Damage Assessment]</td>
</tr>
<tr>
<td><strong>Contractor Caused Delay</strong> [No Time / No Compensation for Extended Overhead / Liquidated/stipulated Damage Assessment]</td>
<td>concurrent with Owner Caused Delay [Time / Compensation for Extended Overhead]</td>
<td><strong>Excusable</strong> [Time / No Compensation for Extended Overhead / No Liquidated/stipulated Damage Assessment]</td>
</tr>
</tbody>
</table>

Figure No. 15 - Net Effect of Potential Concurrent Delay Combinations

Each of the foregoing conditions may result in an excusable, non-compensable delay (depending on the terms of the contract), which in turn typically results in at least four findings and remedies:

- Neither party benefits monetarily from the delay.
- The sole remedy for the delay is an extension of time.
- The right to compensation for either party is deemed offset by the compensation to the other party.
- The delay is treated as excusable and not within the control of either party.

F. Pacing

Pacing occurs when one of the independent delays is the result of a conscious, voluntary and contemporaneous decision to pace progress against the other delay. The quality that distinguishes pacing from concurrent delay is the fact that pacing is a conscious choice by the performing party to proceed at a slower rate of work with the knowledge of the other contemporaneous delay, while concurrent delays occur independently of each other without a conscious decision to slow the work.

By pacing the work, the performing party is exercising its option to reallocate its resources in a more cost effective manner in response to the changes in the schedule caused by the other parent (non-pacing) delay and thereby mitigating or avoiding the cost associated with the resource demands. There may be no need to maintain the original schedule in the face of a known delay caused by the other party – no need to ‘hurry up and wait’. In other words, it is the consumption of float created\(^\text{14}\) in the pacing activity by the occurrence of the parent delay. Pacing delay is a real-life manifestation of the principle that work durations expand to fill the time available to perform them. It can take many forms. Work can be slowed down, resulting in extended work durations, or temporarily suspended, or performed on an intermittent basis. Whatever form it takes, the key is that it results from the performing party’s reasoned decision to keep pace with another activity, which is called the parent delay, which is experiencing a delay.

\(^{14}\) The term ‘creation’ should not be interpreted to mean that total float is increased. In fact, the opposite is true. The parent delay adversely impacts the overall critical path of the project, thereby decreasing total float. What it creates (increases) is relative total float on the path of the paced activity relative to the total float on the path carrying the parent delay.
There are two distinct circumstances to which the term, pacing delay, is often applied. The first circumstance, often referred to as direct pacing, occurs where the duration of a schedule activity is extended due to a delay in a predecessor activity on which the progress of the subject activity is directly dependent. An example would be the pacing of electrical conduit rough-in when the duration of metal stud installation is extended by delays. In such a case, because there is not enough work to sustain the continuous utilization of a full crew, the electrical subcontractor may order a crew size reduction, by temporarily reassigning some workers to other areas, slowing the progress. In either case it extends the overall duration of electrical rough-in. Although this is definitely pacing, it is not considered a pacing delay because the two activities are sequential and not concurrent.

The second type of pacing delay is where the paced activity has no direct dependency on the parent delay activity, sometimes called indirect pacing. The fact that it shares the same time frame is a function of schedule timing as opposed to construction logic. An example of this type of pacing would be the landscaping subcontractor who demobilizes its crew and returns at a later time because critical path work in the building has been delayed.

In this type of pacing, the sole relationship of the paced activity to the parent delay is the fact that the parent delay creates additional relative total float available for consumption by the paced activity. The deceleration is achieved typically by reassignment or reduction of resources or entirely foregoing the procurement of resources that would have been otherwise necessary.

It should be clear that where the pacing defense is raised in answer to the identification of a potential concurrent delay, the pacing delay is not a distinct delay event but an alternate characterization or ‘label’ to describe and explain the concurrent delay event. Therefore, the pacing issue is relevant only to the extent that concurrency of delays is an issue. If there have been no potential concurrent delays identified, then pacing is irrelevant.

The term pacing defense is a misnomer, because paced performance, when properly undertaken, is a proactive rather than a reactive response to another party’s parent delay. The use of the term defense implies that pacing is a forensic excuse rather than a contemporaneous option.

Pacing almost never occurs in the context of a literal method of concurrency analysis. Under the literal theory, the initial delay event would create float within the other near critical simultaneous activities. Since those activities had float relative to the new critical path, there would be no need to consider pacing.

Provided that pacing is not precluded by contract or local law, the contractor’s right to pace its work in reaction to a critical path delay is a generally accepted concept. Thus, the contractor will not be penalized for pacing its work. This is consistent with the majority view that float, a shared commodity, is available for consumption on a ‘first come first served’ basis. Contracts that reserve float ownership to one party or the other may effectively preclude pacing as a management tool.

Pacing is irrelevant without the initial assertion of concurrent delay, and since concurrent delay is irrelevant where compensability is not at issue, the general acceptance of pacing strongly suggests that the contractor’s right to pace would remove the owner’s defense of concurrent delay and thereby make an otherwise non-compensable parent delay a compensable one. Alternatively, the owner can also pace performance. The owner’s legitimate pacing would remove the contractor’s defense of concurrent delay and thereby make an otherwise excusable contractor delay, non-excusable.

G. Demonstrating Pacing

In the absence of clear law or prevailing contractual language, the following criteria provide common sense
guidelines for determining the legitimacy of pacing delays:

1. **Existence of the Parent Delay**

   By definition, pacing delay cannot exist by itself. It exists only in reaction to another delay which is equally or more critical or is believed to be more critical than the paced activity. This calls for the calculation of relative total float between the parent delay and the pacing delay. Also, in cases where many different activities are being performed at the same time, it is unclear who is pacing whom. But one thing is clear: the parent delay must always precede the pacing delay. The existence of a parent delay is a mandatory requirement in legitimizing a pacing delay.

   Quantitatively, the near-critical threshold can serve as a benchmark for the need to analyze for pacing delays, just like it serves to identify concurrent delays.

2. **Showing of Contemporaneous Ability to Resume Normal Pace**

   Pacing is not realistic unless the party claiming it was pacing can show that it had the ability to resume progress at a normal, un-paced rate. Implicit in that party’s ability to show that it could have completed the schedule activity on time if necessary is the fact that the party was able to reasonably determine or reliably approximate when the parent delay would end.

3. **Evidence of Contemporaneous Intent**

   The case can be further strengthened by showing that the pacing was a conscious and deliberate decision that was made at the time of pacing. Without a notice signifying contemporaneous intent to pace, the claimant can use pacing as a hindsight excuse for concurrent delay by offering after-the-fact testimony. Typically, contemporaneous pacing notices are rare in any form, let alone specific written notices. Therefore this should not be a strict requirement of proof.

   Paced performance is inherently risky because it is counter intuitive for any party to intentionally delay its performance on a project where time is of the essence. In order to mitigate such risk, it is always recommended that the party claiming the privilege provide the party responsible for the parent delay with notice of its intent to pace its performance. Unfortunately, such notices are exceedingly rare.

4.3. **Critical Path and Float**

   A. **Identifying the Critical Path**

      1. **Critical Path: Longest Path School vs. Total Float Value School**

      In the early days of the development of the CPM, the longest path was the path with the lowest float. Using simple network logic (finish-to-start) only, the critical path of an un-progressed CPM network calculated using the longest path criterion or the lowest float value criterion is the same.

      It is only when some advanced scheduling techniques are applied to the network model that the paths identified using these different criteria diverge (see Subsection 4.3.D.).

      Most practitioners would agree that the longest path is the true critical path. Even with the use of advanced techniques, if basic network rules (see Subsection 2.1) are observed the total float value is a reasonably accurate way of identifying the critical path. But, note that float values are displayed using workday units defined by the underlying calendar assigned to the schedule activity instead of in 7-day
calendar units. Therefore, activities on a chain with uniform network tension may display different float values.

2. Negative Float: Zero Float School vs. Lowest Float Value School

When a project is behind schedule, the network model may display negative values for float. Technically, this results from the fact that the earliest possible dates of performance for the activities are later than the latest dates by which they must be performed in order for the overall network to complete by a constrained finish date. Thus, the negative value is a direct indication of how many work days the schedule activity is behind schedule.

As discussed in Subsection 4.2.D.2. there are two schools of thought in interpreting the criticality of activity paths carrying negative float values. One school, which will be called the zero float school, maintains that all activities with negative float are, by definition, critical, assuming the definition of critical path is anything less than total float of one unit. The other school, which will be called the lowest value school, insists that only the activity paths that carry the lowest value are critical.

In the context of the two critical path schools, longest path versus total float value, the total float value adherents tend to align with the zero float thinking while the longest path adherents tend to think along the lines of the lowest float value school. However, neither one of these philosophical alignments is guaranteed, nor are they logically inconsistent.

Which one is correct depends on which principles are considered. If only CPM principles are used to evaluate the theories, the lowest value school is correct. The zero float school may have an arguable point if contractual considerations are brought into play, since all paths showing negative float are impacting (albeit not equally) the contractual completion date.

For the purpose of this RP, the procedures and methods use the lowest value theory as the valid criterion for criticality where negative float is shown. Thus, the true float value of a schedule activity carrying negative float will be calculated as the relative total float against the lowest float value in the network. For example, if the lowest float value in the network is minus 100, and another schedule activity shows a value of negative 20, the true float for that schedule activity, based on relative total float, is 80, assuming both activities are defined by the same calendar (see Subsection 4.3.D.2). The potential also exists for fragments of activities to have lower total float than the project’s longest or critical path. This occurs when activities are tied to intermediate project milestones (and not to overall project completion). If such a scenario is observed, the analysis should also consider the contractual relationship or requirement for the intermediate milestones.

B. Quantifying ‘Near-Critical’

The purpose of quantifying the near-critical path is to reduce the effort of identifying and analyzing potential concurrent delays. A rational system of identifying all activities and delays that are near-critical is the first step in objectively streamlining the process of evaluating the schedule for concurrent delays. Thus, if the analyst chooses to analyze all delays and activities on a network, the quantification of near-critical is unnecessary. But in most cases, analyzing all activities, especially on large complex schedules, is excessively time consuming and unnecessary.

Near-critical delays have the greatest potential of becoming concurrent delays. This is because a near-critical delay, upon consumption of relative float against the critical path delay, will become critical. Therefore the near-critical delays are the most likely suspects of concurrency, and must be analyzed for partial concurrency to the extent that the net effect of that delay may exceed such relative float.
The determination of what a ‘near critical’ activity is depends on the following factors:

1. Duration of Discrete Delay Events

The insertion or extraction of delays affects the CPM calculations of a network model. Specifically, the duration of delays modeled in the analysis is directly proportional to the impact such delays have on the underlying network.

Because the effect results from insertion or extraction of delay, this is of obvious relevance to the modeled methods (MIP 3.6, 3.7, 3.8, and 3.9). But, it is also relevant to the dynamic observation methods where the underlying schedule updates were prepared during the project by inserting delay events.

The maximum duration of the set of all delay events would measure the greatest potential effect resulting from insertion or extraction. Averaging the duration of the set of all delay events would provide a less rigorous average measure. The maximum or the average measure is added to the value of the float value of the critical path to yield the near-critical threshold. Any schedule activity or path carrying a float value between that threshold and the value of the critical path is considered near-critical.

The practical effect is that the greater the duration of the delay events used in the model the greater the number of activities that must be considered near-critical and subjected to concurrency evaluation. Under this criterion, the most obvious way of minimizing the number of near-critical activities is to minimize the duration of the delay events. That is, a delay event of relatively long duration can be segmented into smaller sub-events for analysis and documentation.

While ensuring a finer granularity of delay events gives rise to added work in modeling and documenting those delay events, the trade-off is a lesser number of activities to analyze for concurrency.

2. Duration of Each Analysis Interval

The duration of the analysis interval is the length of time from the start of the segment of analysis to the end of that segment. In the dynamic methods (MIP 3.2, 3.3, 3.4, 3.5, 3.7, and 3.9) where the analysis is segmented into multiple analysis intervals, the measure would be the duration of each time period. In the static methods (MIP 3.1, 3.2, 3.6, and 3.8) the duration of the analysis interval is the duration of the entire project or whatever segment of the project is represented by the schedule used for the analysis. Although this would mean that the static methods would have to perform a concurrency analysis on the entire network, it is both impractical and unnecessary to do so. Thus for methods that use the as-built as a component (MIP 3.1, 3.2, and 3.8), determination of near criticality can be made pursuant to the procedure established in Subsection 4.3.C below regarding the as-built critical path.

The concept underlying this criterion is the fact that the potential change in the critical path due to slippage, lack of progress or gain caused by progress during the analysis interval is equal to the duration of that interval. Thus, if the interval is one month, the maximum slippage that can occur, excluding non-progress revisions and delay insertions, is one month. Hence, near-criticality threshold would be set by adding 30 calendar days to the float value of the critical path.

This criterion is most relevant with the dynamic methods (MIP 3.2, 3.3, 3.4, 3.5, 3.7, and 3.9) that use the concept of analysis intervals. An implementation that uses large time periods would have to consider more activities near-critical than one that uses many small time periods. An extreme example of the latter is an as-planned versus as-built analysis that analyzes progress on a daily basis (MIP 3.2). This would have

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15 MIP 3.2 appears in both classifications because under some (but not all) implementations of MIP 3.2, the segmentation is merely a graphical tool for presenting a conclusion derived from a non-periodic analysis. Please refer to MIP 3.2 for details.
a near-critical threshold value of one day over the critical path.

The practical tradeoff is that by increasing the number of analysis intervals one can reduce the work load of concurrency analysis, and vice-versa.

3. Historical Rate of Float Consumption

To augment the previous analysis interval criterion, the rate at which float is being consumed on a given activity-chain over time is worthy of consideration. The rate of consumption should be no more than the duration of the analysis interval per interval. Thus, where the interval is one month, if an activity chain is outside the near-critical threshold but is consuming more than 30 calendar days of float per month in the past updates16, the trend indicates that it would become near-critical in the next period. Therefore, it should be considered near-critical even though it carries more relative float than the duration of the interval.

4. Amount of Time or Work Remaining on the Project

As the project approaches completion, CPM may not be the best tool to assess criticality. This is true especially in a problem project where many activities are being performed out-of-sequence in an attempt to meet an aggressive deadline. Even on a normal project, as the work transitions from final finishes to punch list work, CPM updates may be abandoned in favor of a list or matrix format of work scheduling. It is often said that near the end ‘everything is critical’.

Reduced to an equation, the percentage of activities remaining on the network that should be considered near-critical is proportional to the degree of completion of the schedule.

Therefore, after 90 to 95 percent of the base scope and change order work are complete, the analyst may want to consider all activities on the schedule as near-critical regardless of float.

C. Identifying the As-Built Critical Path

It is impossible to accurately determine the as-built critical path by using only conventional float calculation on the past portion (left) of the data date. Because of this technical reason, the critical set of as-built activities is often called the controlling activities as opposed to critical activities.

One method to show the as-built critical path is to create a collapsible as-built CPM schedule (Subsection 3.8.K.2) where the as-built schedule actual dates are converted into actual activity durations and actual driving lag durations. The total float values of the collapsible as-built schedule can be used to show the as-built critical path if the as-built logic was determined using the enhanced logic rules that not only uses the early-start and early-finish dates to simulate the as-built dates but also determine the proper late start and late finish dates. While there is acknowledgement that this is technically feasible, currently there is no agreement among practitioners on a common set of these enhanced logic rules.

The closest the analyst can come to determining the as-built critical path is to cumulatively collect from successive schedule updates the activities that reside on the critical path between the data date and the data date of the subsequent update. The same technique can be used to determine the as-built near-critical activities. If the updates are available, the following is the recommended protocol.

a. Use all the critical and near-critical activities in the baseline schedule. If modifications were made to the

16 Obviously this would be caused by reasons beyond just pure slippage. An example would be insertion of activities or a change to more restrictive logic.
baseline for analysis purposes, use both sets of critical activities, before and after the modification.

b. For each schedule update, use the critical and near-critical chains of activities starting immediately to the right of the data date.

c. Also use the predecessor activities to the left of the data date that precede the chains found in (b) above.

d. Use the longest path and near-longest path criteria in addition to the lowest float path criterion in identifying the activities.

e. If weather or other calendar factors are at issue, also use a baseline recalculated with an alternate calendar reflecting actual weather or other factors to gather critical and near-critical activities.

An enhanced protocol would add the following sets to the recommended protocol.

f. If appropriate, perform (b) through (d) above using different calculation modes\(^\text{17}\) if they are available.

g. Where significant non-progress revisions were made during the updating process, repeat (b) through (d) using the progress-only, bifurcated schedules (see Subsection 2.3.D)

h. If appropriate, examine the resource-leveled critical path as opposed to hard-tied sequences, sometimes called preferential logic, based solely on resources.

i. Conversely, if resource constraint is at issue and the schedule logic does not reflect the constraint, insert resource-based logic to obtain a critical path that considers all significant constraints.

From the above steps the lowest float path will generally be the as-built critical path. However, the expert must use his/her expert opinion based on all the facts, to identify the as-built critical path from among the identified candidates. Factors to be considered include:

- Was the work critical on any update?.
- Was the work perceived to be critical by project personnel contemporaneously as documented in letters, meeting minutes, etc.?
- Was the work qualitatively significant toward overall outcome based on cost as well as the analyst’s judgment and experience?
- Are their resource restraints not evident in the logic?
- Is the work being performed consistently or piecemeal?
- Does the work drive other subsequent apparently critical work?

Objective identification of the controlling activities is difficult, if not impossible, without the benefit of any schedule updates or at least a baseline CPM schedule with logic. Therefore, in the absence of competent schedule updates, the analyst must err on the side of over-inclusion in selecting the controlling set of as-built activities. The determination must be a composite process based on multiple sources of project data including the subjective opinion of the percipient witnesses. All sources used to identify the as-built controlling path should be tabulated and evaluated for reliability. Contemporaneous perception of criticality by the project participants is just as important as the actual fact of criticality because important project execution decisions are often made based on perceptions. Perceived or subjective as-built critical paths can be based on:

- Interview of the hands-on field personnel.

\(^{17}\) For example, in Primavera Project Planner: retained logic and progress override modes.
• Interview of the project scheduler.
• Contemporaneous non-CPM documentation such as:
  • monthly update reports.
  • meeting minutes.
  • daily reports.

D. Common Critical Path Alteration Techniques

There are various ways of creating, erasing, decreasing, inflating, or hiding float and manipulating the critical path of a CPM network.

These manipulation techniques can be used prospectively during the preparation of the baseline and the project updates as well as in the process of preparing the forensic models (MIP 3.6, 3.7, 3.8, and 3.9). This does not mean that the observational methods (MIP 3.1, 3.2, 3.3, 3.4, and 3.5) are immune from manipulation. Since they rely on the baseline and the updates, the source schedules must be checked for manipulation prior to use in the forensic process. Also, during the forensic process, the dynamic methods are subject to manipulation through the frequency, duration, and placement of analysis intervals (Subsection 4.3.B.2) and through subjective assignment of progress data in reconstructing updates (MIP 3.5).

The use of these techniques per se is not evidence of intentional manipulation. It must be stressed that there are legitimate uses and good reasons, albeit limited, for these features. Even in the absence of ‘good reason’, the feature could have resulted from laziness or even misguided attempts to improve the schedule. At any rate, schedules used for forensic schedule analysis must minimize the use of these techniques (see Subsection 2.1).

The policy of this RP is to be ‘software neutral’. This means that procedures and recommendations are made without regard to the brand or version of software used for analysis. However, the examples of techniques used to manipulate results, listed below, contain descriptions of the features found in some software manufacturer’s manuals

1. Resource Leveling and Smoothing

This technique uses available float to balance the resources necessary for executing the schedule. Some analysts maintain that resource leveling is the technical embodiment of pacing (see Subsection 4.2.F).

Resource leveling is the process of determining and minimizing the effect of resource availability on the schedule. Resource leveling can be used to resolve resource conflicts by rescheduling activities to times when sufficient resources are available. When resources are not available, activities can be split; activity durations can be stretched to reduce their resource per time period requirements; or, activity durations can be compressed to take advantage of ample resource supplies. During forward leveling, activities may be shifted to a later date (the leveled date). In backward leveling, activities may be moved earlier in time.

Resource smoothing is an optional resource leveling method that resolves resource conflicts by delaying activities that have positive float. Resource smoothing uses the available positive float and incrementally increases the availability limits.

2. Multiple Calendars

Float values are displayed using workday units defined in the underlying work-day calendar assigned to the activity instead of in calendar-day units. Therefore, activities in a logic sequence but with different calendars may display different float values.
All things being equal, activities using a more restrictive work-day calendar, such as one that excludes the winter months for work, carry less float than activities with less restrictive work-day calendar. Thus, by adding or removing a few holidays in the calendar, float can be manipulated.

The only way to avoid gaps, discontinuities, and work-day conversions is to use only one calendar consisting of a seven-day week.

3. Precedence Logic / Lead and Lag

Simple logic is finish-to-start with a lag value of zero, denoted as FS0. Other known types of logic relationships are start-to-start (SS), finish-to-finish (FF), and start-to-finish (SF). Most software allows the use of these logic types along with the use of lead and lag values other than zero, including negative values. The use of lag values greater than zero with FS-type of logic absorbs otherwise available float. It is possible to assign lag values that are less than zero, called negative lags. Negative lags associated with the FS-type of logic have the effect of overlapping the associated schedule activities, thereby increasing float.

- **Lag**: An offset or delay from an activity to its successor. Lag can be positive or negative; it is measured in the planning unit for the project and based on the calendar of the predecessor activity.

- **Lead Time**: An overlap between tasks that have a dependency. For example, if a task can start when its predecessor is half finished, the analyst can specify a finish-to-start dependency with a lead time of 50 percent for the successor task. The analyst enters lead time as a negative lag value or as a percent complete lag value in some software packages.

- **Lag Time**: A delay between tasks that have a dependency. For example, if the analyst needs a two-day delay between the finish of one task and the start of another, the analyst can establish a finish-to-start dependency and specify a two-day lag time. The analyst can enter lag time as a positive value.

4. Start and Finish Constraints

Setting a start constraint to a date that is later than what would be allowed by a controlling predecessor would decrease the float on the schedule activity. Similarly, setting a finish constraint to a date that is earlier than what would be allowed by a controlling predecessor would also decrease float on the schedule activity. Both techniques can be used to force activity paths to carry negative float.

There are also features that force the schedule activity to carry no total float or no free float. Also certain types of constraints force the assignment of zero float value by fixing dates on which the activity will be performed, overriding associated precedence logic.

5. Various Calculation Modes

Fundamental schedule and float calculation methods can usually be selected by the analyst, further complicating the effort to identify the critical path and quantify float. Below are examples related to various methods of schedule calculation, duration calculation, and float calculation.

- **Retained Logic**: If the analyst selects retained logic, remaining activities are scheduled with out-of-sequence progress according to the network logic. When used, scheduling software schedules
the remaining duration of an out-of-sequence activity according to current network logic - after its predecessors.

- **Progress Override:** Progress override ignores logic and affects the schedule only if out-of-sequence progress occurs. If the analyst selects progress override, remaining activities are scheduled with out-of-sequence progress as though they have no constraints from incomplete predecessors with start-to-start relationships and can progress without delay. Not only does the successor activity act as if it has only limited predecessor constraints, the float of the predecessor activity also reflects the loss of that successor relationship. Progress override treats an activity with out-of-sequence progress as though it has no predecessor constraints; its remaining duration is scheduled to start immediately, rather than wait for the activities predecessors to complete. However, neither the longest path nor most-negative float techniques can guarantee an accurate depiction of the critical path when using actual dates if out of sequence status is involved.

b. Duration Calculation

- **Contiguous Activity Duration:** Contiguous activity duration requires that work on an activity occur without interruption. For early dates, this type of logic affects the start dates for an activity when the finish dates are delayed by a finish relationship from a preceding activity or by a finish constraint. If the finish dates of an activity are delayed, the start dates are delayed also.

- **Interruptible Activity Duration:** For early dates, interruptible scheduling affects how start dates of an activity are treated when the finish dates are delayed by a finish relationship from a preceding activity or by a finish constraint. If the finish dates of an activity are delayed, the start dates are not delayed. – The duration of the activity is stretched, allowing the work to be interrupted along the way.

6. Use of Data Date

- Reliable calculation of schedule updates requires the use of the concept of data date or status date is generally the starting point for schedule calculations. Generally, the data date is changed to the current date when the analyst records progress.

7. Judgment Calls During the Forensic Process

Any of the above techniques can be abused to effect discretionary decisions by the forensic analyst to influence the analysis in favor of the client. There are two instances in the forensic process that are especially sensitive to such influence because they directly affect the schedule variables at the data line. They are:

- Frequency, duration, and placement of analysis intervals (see Subsection 4.2.A.3).
- Hindsight vs. blindsight update reconstruction (see Subsection 4.2.A.5).

E. Ownership of Float

In the absence of contrary contractual language, network float is a shared commodity between the owner and the contractor. Conventional interpretation of the principle of shared float allows the use of float on a first-come-first-serve basis, thereby allowing the owner to delay activities on that path up to the point where float is consumed. Therefore, as a corollary, if pacing is defined as the consumption of float, it follows that both owners and contractors are allowed to pace non-critical work.
Project float is the time between the last schedule activity on the baseline schedule and the contractual completion date where the contractual completion date is later than the scheduled completion date. In this case, in the absence of contrary contractual language, project float is owned solely by the contractor.

4.4. Delay Mitigation and Constructive Acceleration

A. Definitions

**Acceleration**: All or a portion of the contracted scope of work must be completed by the contractor earlier than currently scheduled. The accelerated work may be required as a result of: (a) direction of the owner or its agents (directed acceleration); (b) conduct of the owner or its agents without explicit direction (constructive acceleration); or (c) events within the responsibility of the contractor resulting in possible delay that the contractor decides to recover or mitigate. Acceleration typically has a cost associated with this performance.

**Directed Acceleration**: Formal instruction by the owner directing the contractor to: (1) complete all or a portion of the work earlier than currently scheduled; (2) undertake additional work; or, (3) perform other actions to complete all, or a portion, of the contract scope of work in the previously scheduled timeframe that otherwise would have been delayed. This could include mitigation efforts that usually have no costs associated with them.

**Constructive Acceleration**: (1) A contractor’s acceleration efforts to maintain scheduled completion date(s) undertaken as a result of an owner’s action or inaction and failure to make a specific direction to accelerate; [4] (2) Constructive acceleration generally occurs when five criteria are met: (a) the contractor is entitled to an excusable delay; (b) the contractor requests and establishes entitlement to a time extension; (c) the owner fails to grant a timely time extension; (d) the owner or its agent specifically orders or clearly implies completion within a shorter time period than is associated with the requested time extension; and, (e) the contractor provides notice to the owner or its agent that the contractor considers this action an acceleration order. [4] (3) Acceleration is said to have been constructive when the contractor claims a time extension but the owner denies the request and affirmatively requires completion within the original contract duration, and it is later determined that the contractor was entitled to the extension. The time extension can be for either additional work or delayed original work. [5] (4) Constructive acceleration occurs when the owner forces the contractor to complete all or a portion of its work ahead of a properly adjusted progress schedule. This may mean the contractor suffers an excusable delay, but is not granted a time extension for the delay. If ordered to complete performance within the originally specified completion period, the contractor is forced to complete the work in a shorter period either than required or to which it is entitled. Thus, the contractor is forced to accelerate the work. [6] (5) Acceleration following failure by the employer to recognize that the contractor has encountered employer delay for which it is entitled to an EOT (extension of time) and which failure required the contractor to accelerate its progress in order to complete the works by the prevailing contract completion date may be brought about by the employer’s denial of a valid request for an EOT or by the employer’s late granting of an EOT. This is not (currently) a recognized concept under English law. [1] (6) Constructive acceleration is caused by an owner failing to promptly grant a time extension for excusable delay and the contractor accelerating to avoid liquidated/stipulated damages. [7]

**Disruption**: (1) An interference (action or event) to the orderly progress of a project or activity(ies). Disruption has been described as the effect of change on unchanged work which manifests itself primarily as adverse labor productivity impacts. [4] (2) Schedule disruption is any unfavorable change to the schedule that may, but does not necessarily, involve delays to the critical path or delayed project completion. Disruption may include, but is not limited to, duration compression, out-of-sequence work, concurrent operations, stacking of trades, and other acceleration measures. [8]
Out-of-Sequence Progress: Significant work performed on an activity before it is scheduled to occur. In a conventional relationship, an activity that starts before its predecessor completes shows out-of-sequence progress. [2]

Delay Mitigation: A contractor’s or owner’s efforts to reduce the effect of delays already incurred or anticipated to occur to activities or groups of activities. Mitigation often includes revising the project’s scope, budget, schedule, or quality, preferably without material impact on the project’s objectives, in order to reduce possible delay. Mitigation usually has no or very minimal associated costs. [4]

Recovery Schedule: A special schedule showing special efforts planned to recover time lost for delays already incurred or anticipated to occur when compared to a previous schedule. Often a recovery schedule is a contract requirement when the projected finish date no longer indicates timely completion. [4] Recovery schedules are usually proposals that must be accepted by the owner prior to implementation.

B. General Considerations

1. Differences between Directed Acceleration, Constructive Acceleration, and Delay Mitigation

In practice, there are subtle distinctions between directed acceleration, constructive acceleration, and delay mitigation. For example, directed acceleration cost implies additional expenditure or money for recovery of either incurred or projected delay, as well as efforts to complete early – all at the direction of the owner. The term constructive acceleration applies to expenditure of money for efforts to recover either incurred or projected delay caused by the owner and without specific direction to do so. Delay mitigation generally refers to no-cost recovery efforts for incurred or projected delay.

In the case of acceleration, constructive acceleration, and delay mitigation, affected activities are usually on the projected critical path; thus, the objective of most acceleration or mitigation is to recover from anticipated delay to project completion. However, acceleration, constructive acceleration, and mitigation can occur with regard to activities that are not on the critical path. For example, an owner might insist that a certain portion of the work be made available prior to the scheduled date for completion of that activity. The contractor may mitigate non-critical delay by resequencing a series of non-critical activities to increase the available float.

There are circumstances in which acceleration measures are used in an attempt to complete the project earlier than planned. Those circumstances are usually classified as: (a) directed acceleration where the owner directs such acceleration and usually pays for the associated additional cost; or (b) voluntary acceleration in which the contractor implements the plan on its own initiative in the hope of earning an early completion bonus. Contractor efforts undertaken during the course of the project to recover from its own delays to activities are generally not considered acceleration, even if the contractor incurs cost as a result.

The causative link between a delay event and cost associated with constructive acceleration is diagramed below. The root cause of the impact results in a construction delay or projects a construction delay. This, in turn, results in the contractor identifying that it needs a time extension and requesting a time extension. The owner denies the time extension request but the need for recovery from the delay remains. The contractor then undertakes acceleration measures that could include increased labor. Increased labor, without a time extension, can result in loss of productivity.
Figure 16 – Constructive Acceleration Flow Chart

A contractor’s cost for acceleration, whether directed or constructive, is generally associated with the effort to engage more resources to perform the work during a unit of time than planned. These increased resources fall into the following major categories: (1) increased management resources; (2) increased equipment usage; (3) increased material supply; and (4) increased labor. The greatest cost associated with acceleration is usually increased labor. Since the amount of actual work remains unchanged in most acceleration efforts (assuming the planned scope of work has not increased), the increase in labor cost is a result of a decrease in labor productivity or the increase in the amount of overtime labor. Decreased labor productivity is caused by disruption to the planned sequence and pace of the labor. The greater the disruption to the work, the greater the inefficiency. Disruption can be the result of having more people working in the planned area during a specific time, or loss of productivity associated with individual workers working more hours than planned.

2. Acceleration and Compensability

Directed acceleration is always compensable to the contractor, although the parties may disagree on quantum. This is true regardless of whether the contractor is accelerating to overcome an owner-caused delay, or to recover from a force majeure event. Constructive acceleration follows this same pattern. If entitlement to constructive acceleration is established, the contractor may recover for a delay caused by the owner that the owner has refused to acknowledge and also for a force majeure event. This is different than the normal rule concerning damages associated with force majeure events. Typically, force majeure events entitle the contractor to time but no money. However, if an owner refuses to acknowledge a time extension for a force majeure event a contractor has no choice but to constructively accelerate so as to avoid the delay and possible liquidated/stipulated damages. As a result, the contractor is entitled to recover its cost associated with that constructive acceleration.

3. Delay Mitigation and Compensability

Delay mitigation is generally achieved through non-compensable efforts. These efforts are usually associated with changes in preferential logic so as to perform the work in a shorter timeframe. Mitigation applies to either incurred or predicted delays. There is no mitigation associated with efforts to complete early. Delay mitigation often has a small cost which is associated with the contractor’s management of the schedule and the overall project. It is generally considered minimal and therefore ignored.

C. Elements of Constructive Acceleration

1. Contractor Entitlement to an Excusable Delay

The contractor must establish entitlement to an excusable delay. The delay can be caused by an action or inaction on the part of the owner that results in delay or it can be a force majeure event. In theory, a
contractor can recover for constructive acceleration for work yet to be done. In this situation the owner takes some action that will result in the contractor expending acceleration costs to recover from the delay. The contractor could assert its entitlement even though the actual acceleration has yet to occur and the actual acceleration costs have yet to occur. In practice, since constructive acceleration occurs after the owner has denied a time extension, it is almost always resolved after the acceleration is complete and the contractor usually is arguing that it was actually accelerated.

2. Contractor Requests and Establishes Entitlement to a Time Extension

The contractor must ask for a time extension associated with the owner’s action or the force majeure event. In that request, or associated with that request, the contractor must establish entitlement to a time extension. The owner must have the opportunity to review the contractor’s request and act upon it. If the contractor fails to submit proof of entitlement to a time extension, the owner is able to argue that the opportunity was never given to properly decide between granting a time extension and ordering acceleration. The level of proof required to be submitted must in the end be sufficient to convince the eventual trier of fact that the contractor “established” entitlement.

In certain situations, it is possible that actions of the owner may negate the requirement for the contractor to request a time extension or to establish entitlement. In this situation, the theory is that the owner has made clear that a time extension will absolutely not be granted. Such cases are difficult to establish.

3. Owner Failure to Grant a Timely Time Extension

The owner must unreasonably fail to grant a time extension. This is closely related to the requirement that the contractor establish entitlement to a time extension. If the owner reasonably denies a request for time, as eventually decided by the trier of fact, then by definition the contractor has failed to prove entitlement. Therefore, the owner’s decision not to grant a time extension where the contractor has shown entitlement must be unreasonable.

4. Implied Order by the Owner to Complete More Quickly

The owner must also, by implication or direction, require the contractor to accelerate. There are several different factual alternatives possible. First, a simple denial of a legitimate time extension, by implication, requires timely completion and thus acceleration. If this denial is timely given, the contractor can proceed. However, the best proof for the contractor is a statement or action by the owner that specifically orders the contractor meet a date that requires acceleration. Second, the owner could deny the time extension request and remind the contractor that it needs to complete on time. This is better than the first alternative above, but not as strong as the next alternative. Third, the owner could deny the time extension request and advise the contractor that any acceleration is the contractor’s responsibility. This is probably the best proof for this aspect of constructive acceleration. All three of these options meet the test for an owner having constructively ordered acceleration. Examples of owner actions that meet this requirement include: (1) a letter from the owner informing the contractor that it must meet a completion date that is accelerated; (2) an owner demand for a schedule that recovers the delay; or (3) the owner threatening to access liquidated/stipulated damages unless the completion date is maintained. The fourth alternative arises when the owner is presented with a request for a time extension but fails to respond. The contractor is faced with either assuming that the time extension will be granted, or accelerating. Under this alternative, the owner’s failure to timely decide, functions as a denial.

5. Contractor Notice of Acceleration
The contractor must provide notice of acceleration. As with any contract claim for damages, the owner must be provided notice of the claim. Even though the contractor has requested and supported the application for a time extension, the contractor must still notify the owner of its intent to accelerate or be actually experiencing ongoing acceleration. This is so that the owner can decide if it actually desired acceleration to occur, or, instead, the owner may decide to grant a time extension.

6. Proof of Damages

The contractor must establish its damages. For loss of productivity claims, the contractor is faced with developing convincing proof of decreased productivity. Actual acceleration is not required. A valid contractor effort to accelerate, supported by contemporaneous records, is sufficient to establish constructive acceleration. It is quite common that contractors accelerate to overcome delays but continue to be impacted and delayed by additional events and impacts that actually result in further delay to the project.

5. CHOOSING A METHOD

This RP discusses the choice of a forensic schedule analysis methodology. Because individuals generally work for one party to a dispute, there is often skepticism about the impartiality of the particular methodology chosen. Therefore, it is vitally important that all practitioners understand clearly what it takes to overcome this skepticism when choosing and using a particular delay evaluation method.

First, each claim is unique in that each deals with a different project, different contract documents, different legal jurisdictions, different dispute resolution mechanisms, and different fact patterns among other project execution factors. Likewise, each method discussed in this RP is different and each has certain technical factors to consider, including advantages and disadvantages. Because of the uniqueness and the need to consider multiple variables it is impossible to recommend one method that is the “best” method, or to rank the methods in order of preference.

Second, the selection of the analytical method should be based primarily on technical considerations related to the purpose, the timing, availability of data, and the nature and complexity of the delay and scheduling information.

Having selected the technically appropriate analysis method based on these criteria, the analyst must now consider the legal criteria, which varies from one jurisdiction to another. It is not possible nor is it the intent to list the selection guidelines of all the legal jurisdictions in this RP. The analyst is cautioned to seek the advice of legal professionals with specialized knowledge of the laws of the jurisdiction and forensic schedule analysis methods. This is true especially if the selection based on technical criteria must be reconciled with a different selection based on legal criteria.

Thirdly, there are a number of qualitative reasons, beyond technical schedule analysis reasons, that should be included in determining which forensic schedule analysis method is to be used for a particular claim. As in any commercial undertaking, while practical considerations are appropriate, these considerations must be secondary to the technical and legal considerations and should be used only when all appropriate technical and legal criteria have been met. Furthermore, the selection decision should be that of the analyst and not that of the client.

There is no requirement that the analyst select only one method to analyze a project. Some cases would necessitate the use of different methods for different phases of the project based on factors, including but not limited to, such as the nature of the claim (compensability versus excusability) and source data availability.

This part of the RP discusses eleven factors that should be considered by the forensic schedule analyst when making a recommendation to the client and its legal counsel concerning this decision. Factors two, three and five
cover technical considerations. Factors one, nine and ten cover legal considerations. And factors four, six, seven, eight and eleven are practical considerations.

The forensic schedule analyst should consider each of these factors, reach a conclusion, and offer a recommendation with supporting rationale to the client and legal counsel in order to obtain agreement prior to proceeding with the work. Advance understanding of the analyst’s scope of work as well as the time, cost and resources required to perform the work should prevent surprise or disagreements during the drafting of the expert report or worse, at deposition.

5.1 Factor 1: Contractual Requirements

When a project is executed under a contract that specifies or mandates a specific schedule delay analysis method, then the choice of method is largely taken out of the hands of the forensic schedule analyst, and contract compliance is the prevailing factor. Some contracts, for example, now require that all requests for time extension (either during the life of the project or at the end of the job) be substantiated through the use of a prospective TIA (similar to MIP 3.7). As noted in this RP, several methods of forensic schedule analysis fall under this generic terminology. Most likely, the forensic schedule analyst will be required to use one of the additive modeling methods, either single base or multiple base, unless there are persuasive reasons why a different method would yield a more credible result. Care should be taken to ascertain whether the contract actually mandates the use of this analytical method in forensic situations (retrospective delay analysis) or whether it is intended solely for use in prospective delay analysis to aid in negotiation of time impacts due to changes or other delays. If the latter is the situation, then the choice of methodology could be made based upon factors other than contractual language.

On the other hand, if the contract documents are silent on which schedule delay analysis method is to be used when attempting to prove entitlement to a time extension or time related compensation, then the forensic schedule analyst is free to use any of the methods identified in this RP to support such requests. However, even when the contract is silent on methodology, contract language may still constrain the forensic schedule analyst’s choice of methods. For example, some contracts contain language requiring that all time extension requests document that the event “…impacted the critical path of the project schedule” or “…caused or will cause the end date of the project schedule to be later than the current contract completion date.” Thus, while this language does not dictate a schedule delay analysis method, it probably compels the forensic schedule analyst to use one of the observational dynamic, additive modeling, or subtractive modeling techniques. Also, it precludes the use of any method that does not identify or analyze a critical path such as a listing of delay events or a bar-chart analysis.

Thus, the first factor to be considered is the existence of an unambiguous contract requirement describing the documentation or method to be used to support requests for time extensions or time related compensation. Forensic schedule analysts should adhere to the requirements of the contract and to the applicable codes and laws under which the contract is governed. However, it is not uncommon that requirements set forth in contracts are unclear or ambiguous (such as a contractual reference to a “but-for TIA”) or patently erroneous references such as contract language requiring the use of an “impacted as-built analysis”. It is hoped that adoption and use of the terminology contained in this RP may help prevent such situations in the future. The forensic schedule analyst may want to use this RP as a mechanism to discuss the issue of differing forensic analysis methodologies with the client, legal counsel, and the other parties and help all focus on an appropriate method to be used.

5.2 Factor 2: Purpose of Analysis

Generally, the purpose of forensic schedule analysis is to quantify delay, determine causation, and assess responsibility and financial consequences for delay. Forensic schedule analysis studies how specific events impact a project schedule. Thus, the forensic schedule analyst uses contemporaneous project documentation to determine which events may have caused delay (including event identification, start and completion dates, activities
impacted by the event, etc.). The forensic schedule analyst then applies or relates these events in some orderly manner to the schedules employed on the project. Once the events are added to, removed from, or otherwise identified in the schedule, a determination can be made concerning whether any or all of the events caused the project to complete later than planned. From this determination, assessment of causation and liability can be made based on the terms and conditions of the contract and the applicable law.

With respect to a particular project, the purpose of forensic schedule analysis is to determine if a party is entitled to time extensions or delay compensation as a result of certain events. Once the forensic schedule analyst has assessed the events that occurred on the project, then consideration should be given to issues such as concurrent delay, pacing delay, delay mitigation, etc. If the forensic schedule analyst, for example, needs to investigate whether concurrent delay is a major factor in the analysis of project delay, then the choice of method will be limited to those methods that specifically provide for concurrent delay identification and analysis.

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<tr>
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<td>OK</td>
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<td>OK</td>
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</tbody>
</table>

Figure 17 – Some Methods are Better Suited for Certain Purposes Than Others

In such a situation, the forensic schedule analyst may be more likely to recommend one of the observational dynamic or modeled methods. If the purpose of the forensic schedule analysis is to demonstrate only excusable, non-compensable delay, numerous methods are available since the forensic schedule analyst will probably not need to deal with concurrent delay. If the purpose is to demonstrate compensable delay, other methods may be more appropriate. If the purpose of the analysis is to investigate the contractor’s ability to complete work early in conjunction with a delayed early completion claim or how the timeframe available for the contractor to perform was compressed, again some schedule delay analysis methods may be better than others. Figure 17 above, generally summarizes the suitability of the nine MIP’s for some typical forensic uses of CPM schedules.

5.3 Factor 3: Source Data Availability and Reliability

As discussed in this RP and emphasized heavily in the source validation protocols, the choice of a particular forensic scheduling methodology is substantially influenced by the availability of source data that can be validated and determined reliable for the purpose of the analysis. If, for example, the project records show that there exists only a baseline schedule but no schedule updates for the duration of the project, then the observational MIP’s 3.3 and 3.4 cannot be utilized.
As a result, it is incumbent on the forensic schedule analyst to determine the amount of contemporaneous project documentation available and assess its quality. Then the forensic scheduler needs to review a sampling of the project documentation to determine if the data is reliable for the purpose of the delay analysis. Once these reviews have been completed, the forensic scheduler can formulate a plan for the forensic schedule analysis effort and make a recommendation concerning which forensic schedule analysis method can and should be employed on the claim. Figure 18 below shows the source schedules that are required to implement the minimum basic protocol for each MIP. Enhanced protocols would typically require additional schedule sources.

![Figure 18 - Source Data Validation Needed for Various Methods](image)

**5.4 Factor 4: Size of the Dispute**

One of the primary factors the forensic scheduler should keep in mind is the size of the dispute or the amount in controversy. In most situations, the choice of the forensic schedule analyst is constrained by how much a client has to spend to increase the probability of successful resolution of the dispute. This is most often determined by how much money is at stake. For example, if the delay damages being sought by the client are approximately US$100,000, then the forensic schedule analyst should recommend a relatively inexpensive forensic scheduling method that is still effective for its intended purpose. On the other hand, if the delay damages sought are US$50,000,000 then the range of methods to be considered is substantially expanded because of the greater scope and costs associated with analyzing a substantially larger claim. The forensic schedule analyst needs to recommend a forensic schedule analysis method that is both cost effective and suitable for the size of the dispute.

**5.5 Factor 5: Complexity of the Dispute**

When considering a forensic schedule analysis method, the forensic schedule analyst should do so with some knowledge of the complexity of the dispute in question and the number of events to be included in the forensic scheduling effort. For example, if the project in question is a linear project of relatively short duration, and only three specific delay events need to be considered, then a simple comparison of the baseline with the as-built schedule may be appropriate. On the other hand, if the project was a complex process facility, with a 5,000+ activity network, and a hundred or so discrete events occurring over a five year period, the forensic schedule analyst may need to recommend one of the observational or modeled methods that divides the project duration into smaller analysis periods to isolate and explain controlling delays. In this context, the forensic schedule analyst should also distinguish between the complexity of the dispute and the complexity of the forensic analysis. Some complex disputes can still be analyzed with a less complex analytical technique. And, some of the methods contained in this RP may not require analysis of every activity on the schedule but can be focused on the critical path and sub-critical paths or on key events and activities only, to reduce both the cost and the complexity of the analysis.

**5.6 Factor 6: Budget for Forensic Schedule Analysis**
Hand in glove with the size and the complexity of the dispute is the client’s budget for the forensic schedule analysis. That is, what can the client afford to spend on forensic schedule analysis? The forensic schedule analyst needs to determine whether there are any budget constraints prior to making a recommendation on forensic schedule analysis methodology. The forensic schedule analyst should also keep in mind the overall cost of the various forensic scheduling methods when making a recommendation. For example, if the delay analysis method requires the testimony of ten or fifteen percipient witnesses in order to properly lay the groundwork for the analysis in arbitration or litigation, this cost too, should be taken into account.

If the law of the contract has a prevailing legal fees provision, then clients and their counsel may be willing to spend more on forensic schedule analysis than if the contract is under conditions commonly called the “American Rule” where each party pays their own cost, regardless of outcome. If the client is prepared to spend only a small amount for a forensic schedule analysis effort, then the forensic schedule analyst should consider using less expensive forensic scheduling methods or cost saving alternatives – such as using the client’s in-house staff for certain tasks rather than outside consultant staff. Or, the forensic schedule analyst may find a method contained in this RP which is appropriate for the situation, but which does not require that all of the validation protocols be performed. If the forensic schedule analyst is required to take short cuts or rely upon the work of others to stay within a very tight budget, the forensic schedule analyst should advise the client and client’s legal counsel of the potential risks of proceeding in this manner. The forensic analysis should keep in mind that if insufficient funding is available for the analysis that would be required to investigate and analyze the case, it may be proper and prudent for the analyst to refuse to undertake the assignment rather than knowingly use a methodology that is not appropriate.

5.7 Factor 7: Time Allowed for Forensic Schedule Analysis

There also may be occasions when the amount of time available to perform and produce a complete forensic schedule analysis is limited. Consideration should be given to the time required for research, data validation, and claim team coordination which may be extensive, as well as production of the report. If the contract contains a fast track arbitration clause which requires that hearings begin within ninety days of the filing of the arbitration demand, and all material to be used in the arbitration is to be exchanged with the other side no less than two weeks prior to the first hearing date, the forensic schedule analyst may be limited to a sixty day timeframe in which to perform the scope of work. In many situations, the need for forensic schedule analysis is not made early enough to allow complete flexibility in the choice of an analytical method or is made at the last minute due to time limitations designating testifying experts. In either situation, the forensic schedule analyst may have a very limited timeframe in which to complete its work. Should this be the case, then the forensic schedule analyst may be constrained to recommend short cuts or a method which can be completed in far less time than other forensic scheduling methods in order to meet the time available to perform the work. Again, the forensic schedule analyst should point out the risks of proceeding in this manner.

5.8 Factor 8: Expertise of the Forensic Schedule Analyst and Resources Available

If the forensic schedule analyst is experienced with only two or three of the methods identified in this RP and will be subject to challenge from the other side during voir dire, the forensic schedule analyst may be compelled to recommend use only of methods with which the analyst has experience. If the analyst determines that another method in which the analyst has little or no experience is more appropriate to the particular case then the analyst should be prepared to disclose that fact to the client. Additionally, if the forensic schedule analyst is to perform all analytical work individually with no assistance, the analyst may be constrained to recommend simpler methods which can be performed individually and will not require a staff of additional people processing data, making computer runs, etc.
5.9 Factor 9: Forum for Resolution and Audience

During initial discussions concerning the potential engagement, the forensic schedule analyst should seek advice from the client and its legal counsel on the most likely dispute resolution forum. What the forensic schedule analyst should seek is an opinion from those involved in the project, and their legal counsel, on whether the claim is likely to settle in negotiation, mediation, arbitration (and if so, under what rules), or litigation (and if so, in which court). If there is good reason to believe that all issues are likely to be settled at the bargaining table, or in mediation, then the range of options for forensic scheduling methods is wide open as the audience is only the people on the other side and they may be motivated, persuaded or willing to make decisions based upon a forensic schedule analysis method different than that specified in the contract. Almost any option which is objective, accurately executed and is persuasive is legitimately open for consideration. On the other hand, if legal counsel believes that the issue will end up in court or a government agency board, then the range of options available may be considerably narrowed because many courts and boards have adopted their own rules concerning forensic scheduling.

5.10 Factor 10: Legal or Procedural Requirements

Depending upon the forum for the dispute and the jurisdiction, the forensic schedule analyst must be aware of or ask about any contractual, legal, or procedural requirements that may impact the forensic analysis.

There may be other contractual, legal, or procedural rules impacting forensic scheduling that the forensic scheduling analyst should consider when making a recommendation concerning which forensic scheduling methodology to use on a particular claim. Consultation with the client’s legal counsel on these issues is essential.

5.11 Factor 11: Custom and Usage of Methods on the Project or the Case

The final factor to be considered is past history and methods. Typically, a forensic schedule analyst is not engaged until after preliminary negotiations have failed. Thus, the forensic schedule analyst needs to consider what delay analysis method was employed by the client and their staff earlier during the project, which was not acceptable to the other side in prior negotiations. Knowing this, the forensic schedule analyst generally should not recommend use of this technique, as it has already proven unsuccessful, unless the scheduler can determine that the client staff performed the method erroneously in their early efforts or that the basis of the previous ejection of the method was clearly erroneous. Additionally, the forensic scheduler should take into consideration the method that had been previously employed unsuccessfully, if known.

Not all of the above factors will be applicable to all delay claims, obviously. Nevertheless, a prudent forensic schedule analyst should consider each of the above factors, as well as any other relevant factors that emerge, to determine which apply to the claim at hand. Once these are identified, including their potential synergistic effect upon each other, the forensic schedule analyst should discuss each applicable factor with the client and their legal counsel prior to making a recommendation as to which method should be employed for the delay analysis. Failure to consider these factors could lead to substantial difficulties later on in claim settlement negotiations, arbitration, or litigation.

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Note: The diagram illustrates the retrospective analysis table with columns for Static Logic, Dynamic Logic, Additive, and Subtractive categories, detailing various analysis methods and their corresponding outcomes.
APPENDIX B: FIGURE 2 - TAXONOMY OF FORENSIC SCHEDULE ANALYSIS
AACE International Recommended Practice No. 25R-03

ESTIMATING LOST LABOR PRODUCTIVITY IN CONSTRUCTION CLAIMS

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A. INTRODUCTION

One of the most contentious areas in construction claims is the calculation or estimation of lost productivity. Unlike direct costs, lost productivity is often not tracked or cannot be discerned separately and contemporaneously. As a result, both causation and entitlement concerning the recovery of lost productivity are difficult to establish. Compounding this situation, there is no uniform agreement within the construction industry as to a preferred methodology of calculating lost productivity. There are, in fact, numerous ways to calculate lost productivity. Many methods of calculation are open to challenge with respect to validity and applicability to particular cases -- thus making settlement of the issue on a particular project problematic.¹

What is productivity in construction and how is it measured? Several authors have answered this question in the following manner.

“...productivity refers to quantities produced per employee hour of effort...” and further is “...defined as the ratio of output to input... Productivity can be defined by any of the equations ..."

\[
\text{Productivity} = \frac{\text{Output}}{\text{input}} = \frac{\text{Units}}{\text{work-hours}} = \frac{\text{(Total output)}}{\text{(Total work-hours)}}\]

“Productivity is measured generally by the output per hour of input.”³

“Productivity: [A] relative measure of labor efficiency, either good or bad, when compared to an established base or norm as determined from an area of great experience. Productivity changes may be either an increase or decrease in cost.”⁴

“Productivity is defined as the craft hours necessary to produce a unit of finished product.”⁵

Simply stated then, productivity is a measurement of rate of output per unit of time or effort usually measured in labor hours. For example, cubic yards/cubic meters of concrete placed, linear feet/meters of conduit installed or pipe placed, etc. per crew hour or some other standard measure.

Productivity loss, therefore, is experienced when a contractor is not accomplishing its anticipated achievable or planned rate of production and is best described as a contractor producing less than its planned output per work hour of input. Thus, the contractor is expending more effort per unit of production than originally planned.⁶ The result is a loss of money for a contractor. Therefore, a challenging aspect of construction cost control is measuring and tracking work hours and production in sufficient detail to allow analysis of the data in order to determine the root cause(s) of poor labor productivity, should it occur.

Productivity is critically important in the context of construction contracts, both large and small. Construction contractors are typically paid for work completed in place that conforms to the terms of the contract. This is sometimes referred to as pay item work and is generally true whether the contract is lump sum/firm fixed price, cost reimbursable, target cost, unit cost or pay item work or as a percentage of previously defined categories of work, often referred to as a schedule of values or bill of quantities. That is, unlike automotive manufacturers, construction contractors are rarely paid on the basis of the entire completed product. And, unlike craft labor, construction contractors are rarely paid by hours of labor. Therefore, productivity is related to project cash flow and profitability.
All too often in construction, the terms “productivity” and “production” are used interchangeably. This is, however, incorrect. Production is the measure of output (i.e., things produced) whereas productivity is the measurement of the production. The following two formulas can be used to calculate these two terms.

\[
\text{Productivity} = \frac{\text{Output (units completed)}}{\text{Input (work or equipment hours)}}
\]

\[
\text{Productivity Factor} = \frac{\text{Actual Productivity}}{\text{Baseline or Planned Productivity}}
\]

Given this set of operating terms, it is therefore possible for a contractor to achieve 100% of its planned production but not achieve its planned productivity. That is, a contractor could well be accomplishing the planned rate of production of 300 linear feet of pipe/day in the ground but be expending twice the amount of labor planned to accomplish this daily production rate, for example. In this case, the contractor would be accomplishing 100% of planned production but operating at 50% productivity.

Thus, production and productivity are not reciprocal numbers. It does not necessarily follow that if a contractor is 75% productive then they are 25% inefficient. In the context of this Recommended Practice, production is the measure of output (i.e., how many feet or meters of pipe to be installed per work hour) while productivity is the measure of input (i.e., how many labors hours it takes to install a foot or meter of pipe).

Measurement and allocation of responsibility for loss of productivity can be difficult. There are a number of reasons for this difficulty.

- Lost productivity resulting from some action which is the responsibility of the owner, may not be easily detected or observed at the outset. Unless a contractor has a good productivity monitoring plan, well known to field project management staff, all that may be known at the outset of a problem is that the field crews are not completing work activities as planned, and project schedule, costs and cash flow are suffering as a result. As a result, appropriate written notice to the project owner is often not promptly filed, kicking off more discrete and detailed project monitoring efforts.

- Productivity is frequently not discretely tracked on construction projects in a contemporaneous manner. Unless a contractor uses some sort of structured earned value system for tracking output units and input units, there is no way to measure productivity contemporaneously. Thus, productivity losses can be difficult to prove with the degree of certainty demanded by many owners.

- Lost productivity is, all too often, calculated at the end of a project during preparation of a claim or request for equitable adjustment. As a result, often times only a gross approximation or a total cost estimate can be made.

- Complicating the issue even more, there are myriad ways to calculate lost productivity. There is no common agreement amongst cost professionals as to how such lost hours should be calculated. Notwithstanding this statement, there is general agreement among cost professionals that a comparison to unimpacted work on the project is generally preferred when there is sufficient data available.

- The quality of some of the methods' results is not always repeatable, leading to low confidence in the resulting analysis. Often two methods are used to compare results as a check with seemingly wide variances observed that cannot be easily understood or reconciled.

- Finally, once lost productivity is calculated, it is still difficult to establish causation. Contractors tend to blame such losses on owners and ask to be compensated. Owners, on the other hand, often blame a
bad bid or poor project management and thus deny additional compensation for lost productivity. Given this situation, the root cause of lost productivity is frequently a matter in dispute between owners, contractors and subcontractors.

The key to reconstructing productivity information in support of a lost productivity claim is good record keeping throughout the entire project. From the very start of the project, the contractor ought to establish a uniform system of capturing and recording field labor productivity information on a contemporaneous basis. Actual labor productivity ought to be compared on a routine basis to as-bid or as-planned labor productivity to determine how the project is progressing against the plan. The earlier productivity loss can be detected on a project, the greater the likelihood that corrective action can be implemented to mitigate damages. If progress is not per plan, analysis for causation must be made. In the event that poor productivity is, to a greater or lesser extent, brought about by some action or lack of action by the owner, then appropriate written notice should be filed. Regardless of causation, corrective action ought to be initiated as soon as the decline in labor productivity is detected.

B. PURPOSE

This Recommended Practice focuses on identification of various methods for estimating lost labor productivity in construction claims. Often the claim is the result of one or more change order requests that cannot be fully resolved to capture their full and final effect on the entire project cost and schedule. Specifically, this Recommended Practice examines the issue in terms of claims for cost recovery of lost productivity. Therefore, the purpose of the Recommended Practice is to

- Identify Lost Productivity Estimating Methodologies: That is, survey as many of the various methodologies employed in litigation throughout North America as can be identified;

- Rank Order the Methodologies: That is, based on reliability, professional acceptance, case law and construction claims literature, rank the identified methodologies from most to least reliable with respect to documenting estimating damages in claim situations. While it may not be possible to state with certainty which methods are absolutely most or least reliable, it can be stated that under certain sets of circumstances some methods are generally considered more reliable than others. (CAUTION: This Recommended Practice was prepared on the basis of the author’s understanding of Canadian and U.S. case law. It is recommended that anyone preparing a lost productivity claim seek appropriate legal advice on the methodology to be used. This is especially true if the claim is being pursued under national law other than Canada or the United States.)

- Define and Discuss Each Methodology: That is, discuss the method and how it is employed. Also, when possible, discuss the strong and weak points of each method;

- Identify Selected Studies Applicable to Each Methodology: Herein, identify as many studies and professional or technical papers as possible which will help the practitioner in learning more about and/or employing a particular method.

It needs to be noted that this Recommended Practice does not define in detail how one should properly perform the various analytical methods identified herein. The Recommended Practice gives a brief description of each method only in an effort to help claimants properly identify the method. That is, different claimants may have differing nomenclature for the same methodology. In this case, the brief description of each method is intended to help overcome this situation.

B.1 Common Causes of Lost Productivity

On construction projects there are numerous circumstances and events which may cause productivity to decline. A review of two relatively recent publications results in the following list of causes which, while not all inclusive, fairly well covers the majority of situations encountered on a construction project. The circumstances set forth below may all impact labor productivity. However, for a contractor to successfully
recover damages due to lost productivity from a project owner, the contractor will need to clearly demonstrate that the root cause of the event or circumstance was something for which the owner or one of the owner’s agents was responsible. Additionally, the contractor must be able to show a cause and effect relationship between the event and the impact to labor productivity in order to recover damages (i.e., costs and/or time). However, the recoverable damages are not limited to direct costs. They may also include ripple damages or indirect costs, to the extent that a cause and effect relationship can be established between the downstream effects and the originating event.

- **Absenteeism and the missing man syndrome** – When a crew hits its productive peak the absence of any member of the crew may impact the crew’s production rate because the crew will typically be unable to accomplish the same production rate with fewer resources or, perhaps, a different mix of skill and experience levels.

- **Acceleration (directed or constructive)** – The deliberate or unintentional speeding up of a project may result in lengthy periods of mandatory overtime, the addition of second shifts, or the addition of more labor beyond the saturation point of the site or that can be effectively managed or coordinated, all of which may have distinct impacts on productivity.

- **Adverse or unusually severe weather** – Some bad weather is to be expected on almost every project. But, pushing weather sensitive work from good weather periods into periods of bad weather, or encountering unusually severe weather, may impact productivity (e.g., earth backfill and compaction operations pushed into wet weather periods).

- **Availability of skilled labor** – To be productive, a contractor must have sufficient skilled labor in the field. To the extent that skilled labor is unavailable and a contractor is required to construct a project with less skilled labor it is probable that productivity will be impacted.

- **Changes, ripple impact, cumulative impact of multiple changes and rework** – All projects encounter some change during construction. This is to be expected. Some authors believe that 5 – 10% cost growth due to changes is the expected norm. However, major change (change well beyond the norm), change outside the anticipated scope of work (cardinal change), multiple changes, change’s impact on unchanged work, or the cumulative impact of changes may all impact productivity. The need to tear out work already in place, the delays attendant to changes, the need to replan and resequence work, for example, may also cause productivity to decline.

- **Competition for Craft Labor** – If a nearby project(s) commences concurrently with the execution of a project that was estimated and planned to utilize a stated level of labor skill and availability, and a competition for that skilled labor base ensues, productivity may be adversely impacted. Financial incentives, work rule changes and other issues may result in labor leaving one site for another, resulting in lower productivity and increased costs for the first contractor. Further, the replacement labor may be more costly and less skilled.

- **Craft turnover** – If a crew suffers from continual craft turnover, it is unlikely that they will achieve good productivity simply because one or more members of the crew may be on the learning curve, and thus decrease the overall productivity of the entire crew.

- **Crowding of labor or stacking of trades** – To achieve good productivity each member of a crew must have sufficient working space to perform their work without being interfered with by other craftsmen. When more labor is assigned to work in a fixed amount of space it is probable that interference may occur, thus decreasing productivity. Additionally, when multiple trades are assigned to work in the same area, the probability of interference rises and productivity may decline.

- **Defective engineering, engineering recycle and/or rework** – When drawings or specifications are erroneous, ambiguous, unclear, etc., productivity is likely to decline because crews in the field are
uncertain as to what needs to be done. As a consequence, crews may slow down or pace their work, or have to stop all together while they wait for clear instruction.

- **Dilution of supervision** – When crews are split up to perform base scope work and changed work in multiple locations or when work is continually changed or resequenced, field supervision is often unable to effectively perform their primary task – to see that crews work productively. Field supervision ends up spending more time planning and replanning than supervising. It is probable that productivity will decline because the right tools, materials and equipment may not be in the right place at the right time.

- **Excessive overtime** – Numerous studies over many years have consistently documented the fact that productivity typically declines as overtime work continues. The most commonly stated reasons for this result include fatigue, increased absenteeism, decreased morale, reduced supervision effectiveness, poor workmanship resulting in higher than normal rework, increased accidents, etc. One author has gone so far as to suggest that “…on the average, no matter how many hours a week you work, you will only achieve fifty hours of results.” The thought underlying this statement is that while overtime work will initially result in increased output, if it is continued for a prolonged period, the output may actually decline for the reasons stated earlier. Thus, long term overtime may lead to increased costs but decreased productivity. The effect of continued overtime work on labor productivity is, perhaps, one of the most studied productivity loss factors in the construction industry. The large number of studies contained in Appendix D is testimony to this fact.

- **Failure to coordinate trade contractors, subcontractors and/or vendors** – If the project management team fails to get subcontractors, material or equipment to the right place at the right time, then productivity may decline as crews will not have the necessary resources to accomplish their work, various trades interfere with others or work is not available to the crews to perform.

- **Fatigue** – Craftsmen who are tired tend to slow down work, make more mistakes than normal, and suffer more accidents and injuries, thus productivity may decrease for the entire crew.

- **Labor relations and labor management factors** – When there are union jurisdictional issues, industrial relations issues, unsafe working conditions or other safety issues, multiple evacuation alarms in existing facilities, untimely issuance of permits, access issues, etc. labor productivity may be adversely impacted in multiples ways.

- **Learning Curve** – At the outset of any project, there is a typical learning curve while the labor crews become familiar with the project, its location, the quality standards imposed, laydown area locations, etc. This is to be expected and is typically included in as-bid costs. However, if the work of the project is shut down for some period of time and labor crews laid off, then when work recommences the labor crews brought back to the project may have to go through another learning curve. This is probably an unanticipated impact to labor productivity. If this happens more than once, then each time a work stoppage occurs another learning curve productivity loss impact may occur.

- **Material, tools and equipment shortages** – If material, tools or construction equipment are not available to a crew at the right location and time, then the crew’s productivity will probably suffer as they may be unable to proceed in an orderly, consistent manner. Similarly, if the wrong tools or improperly sized equipment is provided, productivity may also suffer.

- **Overmanning** – Productivity losses may occur when a contractor is required to or otherwise utilizes more personnel than originally planned or can be effectively managed. In these situations, productivity losses may occur because the contractor may be forced to use unproductive labor due to a shortage of skilled labor; there may be a shortage of materials, tools, or equipment to support the additional labor; or the contractor may not be able to effectively manage the labor due to a dilution of supervision.
Poor morale of craft labor – When work is constantly changed or has to be torn out and redone, etc. the morale (i.e., enthusiasm for their work) is likely to suffer. When this occurs, productivity may decline.

Project management factors – A result of poor project management may be the failure to properly schedule and coordinate the work. Work that is not properly scheduled, shortage of critical construction equipment or labor, and incorrect mix of labor crews may result in decreased productivity because crews may not be able to work as efficiently as they would otherwise do. Improperly planned and implemented project initiation procedures may also lead to lost labor productivity. For example, mobilizing labor prior to having access to site electrical power or prior to having adequate site parking can both impact early on labor productivity. Additionally, poor site layout can contribute to loss of productivity. If, for example, crews have to walk a long way to lunch rooms, tool cribs, laydown areas, washrooms, entrances and exists, etc., then productivity may suffer as a result. In design build or EPC projects, mobilizing to the field prematurely before engineering is sufficiently complete to support efficient work schedules may lead to rework and inefficiencies.

Out of sequence work – When work does not proceed in a logical, orderly fashion productivity is likely to be negatively impacted as crews are moved around the site haphazardly, for example.

Rework and errors – When work in the field must be done more than once in order to get it right, productivity may suffer as a result.

Schedule Compression Impacts on Productivity – Contractors are not legally bound to prove that contract performance was extended to recover for lost productivity. When there are delays early on in the project, the compression of the overall timeframe for later activities is often looked to as the way to make up for delays and finish the project on time. From a strict scheduling perspective this may be possible to do without accelerating individual work activities by utilizing float in the project’s overall schedule. However, on many projects, schedules are not fully resource loaded. As a consequence, a properly updated schedule reflecting the delays may show the project finishing on time, without shortening individual activities. It may result in overmanning of the work by the contractor due to the shortening of the overall duration allowing the contractor to complete the total remaining work. This is known as schedule compression. Schedule compression, when associated with overmanning often results in significant productivity losses due to dilution of supervision, shortages of materials, tools or equipment to support the additional labor, increased difficulty in planning and coordinating the work and shortages of skilled labor.

Site or work area access restrictions – If a work site is remote, difficult to get to, or has inefficient or limited access then productivity may suffer because labor, equipment and materials may not be on site when and as needed to support efficient prosecution of the work. In addition, productivity losses may occur when access to work areas are delayed or late and the contractor is required to do more work in a shorter period of time, which may result in overmanning, dilution of supervision and lack of coordination of the trades.

Site conditions – Physical conditions (such as saturated soils); logistical conditions (such as low hanging power lines); environmental conditions (such as permit requirements prohibiting construction in certain areas during certain times of the year); legal conditions (such as noise ordinances precluding work prior to 7:00 AM [0700 hours] or after 6:00 PM [1800 hours]) may all negatively impact productivity on a project.

Untimely approvals or responses – When project owners, designers and/or construction managers fail to respond to contractually required submittals or requests for information in a timely manner, productivity on a project may decline as crews may not have authority or sufficient knowledge to proceed with their work.
Once the first productivity loss has been detected, the contractor should reconfirm the baseline estimate to ascertain that the project estimate is basically correct. In doing so, the contractor can insure that the productivity loss detected is not simply the result of comparing field productivity to a flawed baseline. Once this effort is complete the root cause of the productivity loss needs to be determined.\textsuperscript{15} If the causation is found to be something for which the owner is liable, recommended practice is to follow the mandates of the contract with respect to providing written notice to the appropriate party as soon as possible. Subsequently, recommended practice is to gather all necessary supporting documentation and file the lost productivity claim as prescribed in the contract. Some contracts allow claim filing within a specified period of time after the notice of claim was filed whereas other contracts provide for claim filing within so many days after the event or circumstance has passed. Regardless, the contractor seeking to recover lost productivity costs should follow the mandates of the contract as closely as possible.

**B.2 Recovery of Lost Productivity Cost**

Based upon the definition of productivity set forth at the outset of this Recommended Practice and a review of the causation factors, lost productivity can be translated to “…the increased cost of performance caused by a change in the contractor’s anticipated or planned resources, working conditions or method of work.”\textsuperscript{16} While the general cause(s) of lost productivity may be easy to speculate upon (at least in hindsight), the contractor seeking to be compensated for a cost increase must first demonstrate entitlement, that is, a contractual right to recover damages, to the level of certainty required by decision makers or the trier of fact. Second, the contractor must sufficiently prove causation, the nexus between entitlement and damages.\textsuperscript{17} The resulting damages (cost) are an outgrowth of the change in Output/Input. Lost productivity is the difference between baseline productivity and that actually achieved.

\[
\text{Lost Productivity} = \text{Productivity Baseline} - \text{Productivity Actual}
\]

Baseline productivity can be determined by measurements of input and output in unimpacted or the least impacted periods of time on the project. When this data is not available, estimated or analytically determined baseline productivity may be substituted.

While it is beyond the scope of this Recommended Practice to discuss the legal elements of entitlement and causation in detail, it is noted that to recover lost productivity costs (damages) the contractor typically must sufficiently demonstrate the following.

- Compliance with the notice requirements of the contract.
- Events occurred during the performance of the work, which were unforeseeable at the time of contract execution or a preceding change order(s).
- The events were beyond the control of the contractor seeking compensation, whether it is the contractor, its subcontractors, vendors or suppliers, at any tier.
- The events were caused by the owner or some entity for whom the owner is responsible (i.e., the design professional, construction manager or an independent prime contractor, etc.). Or, in the alternative, the events were caused by situations for which the owner assumed contractual liability (i.e., a force majeure situation or differing site condition, etc.).
- Recoverability for the resulting damages is not barred by the terms of the contract (e.g., exculpatory clauses such as a no damages for delay clause which may be upheld in the jurisdiction or overcome by events beyond the contemplation of the parties or intentional, willful, or grossly negligent conduct of the party seeking enforcement of such a clause).
- The events caused a change in the performance of the work and resulted in increased costs and/or time required to perform the work (i.e., work was resequenced, means and methods were changed, it took longer to perform the work, the work cost more due to performing work in bad weather, etc.).
Only after all of the above has been sufficiently documented and demonstrated, is the contractor able to present its damages (also referred to as “quantum” by attorneys) for consideration. It is the calculation of potential damages or the estimate of damages incurred due to lost productivity that this Recommended Practice is intended to address.

It must also be noted the optimal productivity is rarely if ever at the maximum production rate. Lost productivity claims must compare planned and documented productivity rates with actual productivity rates. A claim of “low productivity” is not likely to prevail. While non-optimal productivity is inefficient and costly, it may be driven by factors known at the time of bidding and thus not give rise to additional compensation. For example, a project bid with a tightly constrained schedule may dictate higher costs and poor productivity in order to accomplish the work in a shortened timeframe. But, if this is an as-known condition at the time of bidding, a claim of poor productivity is not likely to be successful.

C. RECOMMENDED PRACTICE

C.1 Methods of Estimating Lost Productivity

Listed below, in outline form, are various identified methods for estimating lost productivity. These methods are listed in order of preference. The recommended order of preference of the applicability of the studies and methods set forth below is based upon the weight of published literature. That is, Project Specific Studies are preferred to Project Comparison Studies. Project Comparison Studies are likely to be given greater weight than Specialty Industry Studies. Specialty Industry Studies are generally considered more reliable than General Industry Studies, and so on and so forth. Within each category, this Recommended Practice has likewise placed the methodology in order of preference. For example, properly performed measured mile studies are preferred to earned value analyses which, in turn, are considered more credible than work sampling or craftsmen questionnaires. Following this listing is a discussion of each method and a commentary of the method’s utility in a claim or dispute situation.

- **Project Specific Studies**
  - Measured Mile Study
  - Earned Value Analysis
  - Work Sampling Method
  - Craftsmen Questionnaire Sampling Method

- **Project Comparison Studies**
  - Comparable Work Study
  - Comparable Project Study

- **Specialty Industry Studies**
  - Acceleration
  - Changes, Cumulative Impact and Rework
  - Learning Curve
  - Overtime and Shift Work
  - Project Characteristics
  - Project Management
  - Weather

- **General Industry Studies**
  - U.S. Army Corps of Engineers Modification Impact Evaluation Guide
Cost Basis

- Total Unit Cost Method
- Modified Total Labor Cost Method
- Total Labor Cost Method

Productivity Impact on Schedule

- Schedule Impact Analysis

Inclusion of a methodology in this Recommended Practice is not intended to be an endorsement of the methodology by AACEI or those that contributed to this Recommended Practice. Rather, inclusion is simply acknowledgement that the methodology is recognized in the construction industry and has been used, with more or less success, in the legal systems in North America to estimate damages arising from certain situations.

C.2 Recommended Practice – Order of Preference

Prior to initiating a loss of productivity analysis, the claimant should carefully consider whether the productivity loss can be recast as an impact of specifically definable extra work. If so, then such productivity loss ought to be incorporated into the estimate of the extra work and resolved in that manner.

A review of U.S. and Canadian case law leads to the conclusion that Courts, Boards of Contract Appeals and other legal forums are more favorably impressed by damage calculations related directly to the project in dispute and supported by contemporaneous project documentation. Therefore, recommended practice for one preparing a lost productivity calculation is to utilize, if possible, one of the techniques listed in the category Project Specific Studies. These methodologies, discussed in further detail below, are project specific and supported by people and records directly involved at the time of the dispute or the disputed work. If there is insufficient information available from contemporaneous project documentation to support one of these techniques, recommended practice then is to use one of the methods listed under the category Project Comparison Studies. These methodologies, too, are project specific but rely upon different forms of contemporaneous documentation.

It is recognized that contemporaneous project documentation is not always available to one tasked with estimating lost productivity. Estimated costs are, of course, recognized as a legitimate way to calculate damages once entitlement and causation are sufficiently proven. North American legal systems recognize that damages cannot always be calculated with mathematical certainty. Further, it is recognized that contractors frequently have to prepare and live with cost estimates. Therefore, in the absence of other proof of damages, the legal system may allow estimates to establish damages. Estimated damages may be acceptable, under proper circumstances, but are more subject to challenge than direct project costs. Of the damage calculation and estimating methods, recommended practice is to use first, one of the studies listed in the Specialty Industry Studies category. These are specialty studies of specific types of problems and are, generally, based on some number of actual construction projects. Of course, to utilize one of these studies, the causation of the lost productivity should be appropriate for the particular problem studied.

If none of the specialized studies are applicable to the situation, recommended practice is to utilize one of the studies listed in the General Industry Studies categories. These studies are more subject to challenge because they are industry wide and not subject or project specific. Further, the basic data is sometimes derived from a non-construction environment. Finally, these studies were, by in large, intended as “forward pricing guides” and thus their intended purpose was distinctly different.
Notwithstanding these criticisms, in the absence of more reliable techniques, claimants have been allowed to use these studies once entitlement and causation have been sufficiently proven.

If the contractor preparing a lost productivity damage calculation can demonstrate entitlement and causation but is unable to utilize one of the techniques previously listed, recommended practice is to use one of the methods listed in the Cost Basis category. To successfully utilize one of these techniques, the claimant has to overcome some difficult legal hurdles, discussed in more detail below. But, if these challenges can be met, then these techniques may be allowed as a measure of lost productivity.

Finally, while it is not within the scope of this Recommended Practice to discuss the details of scheduling and schedule delay analysis, recommended practice is to feed back the results of a lost productivity analysis into a schedule to determine whether there are further impact costs that should be recoverable. Recommended practice is to utilize the approach listed in the Productivity Impact on Schedule category and employ an appropriate schedule delay analysis technique.

A note of caution is in order at this point. Most lost productivity claims involve situations where the loss of productivity is due to multiple causes. It cannot be emphasized enough that calculation of productivity loss is not a simple exercise. As a result, it is critical that the root cause of the lost productivity be determined from project records or project personnel before deciding how to proceed to estimate the labor impact. In cases where there are multiple causes of productivity loss, the individual preparing the claim may be required to perform multiple estimating analyses and then merge them together to rationalize the results, but not overstate the estimated productivity loss.

Most of the following methodologies have developed procedures to follow when applying the method to a situation. Claimants using one of more of these methods must, in order to maintain credibility, follow the procedures outlined in the method being utilized. Some of the more common mistakes made in estimating lost productivity include the following:

- Calculating the percentage change on a project on a cost rather than a labor hour basis;
- Applying calculated lost productivity factors to as-bid labor hours rather than actual labor hours;
- Applying calculated factors to all hours on the project rather than the hours during a certain impacted period;
- Failing to account for typical learning curve productivity factors when calculating lost productivity;
- Failing to deduct the additional labor hours already paid for in change orders or extra work orders, before applying the productivity loss factor(s) estimated; or,
- Failing to take into account and deduct other factors, which impacted productivity but which are not recoverable under the terms of the contract.

Errors, such as those listed above, in applying a method to the situation being analyzed must be carefully guarded against. If mistakes such as these are allowed to creep into the productivity loss analysis, then the credibility of the analysis will be undercut and the likelihood of cost recovery reduced.

Finally, it is noted that civil litigation in Canada and the U.S. rests on the “preponderance of evidence” test. That is, it is more likely than not that “x” event or occurrence resulted in “y” damages. Therefore, someone preparing a productivity loss analysis may want to employ more than one of the methods listed herein. From a practical point of view, and this is especially applicable if the productivity analysis is not based on contemporaneous project records, if two or more methods independently applied result in comparable results, the trier of fact (be it judge, jury or arbitration panel) is more likely to accept the results. Again, it needs to be noted that this Recommended Practice has been derived from a review of U.S. and Canadian legal decisions. To the extent that someone is pursuing a loss of productivity claim in
a legal forum other than in the U.S. or Canada, legal advice should be obtained concerning how legal
forums in those jurisdictions deal with the issue of lost productivity.

C.3 Discussion of Recommended Practice

**Project Specific Studies** – As noted earlier, when a dispute arises over lost productivity, calculations
based upon contemporaneously created project documentation from the project in dispute, supported
by personnel who were actually involved in the project and disputed work activities are the most
credible. Accordingly, when calculating lost productivity, recommended practice is to utilize one of
the following techniques, when possible.

There are two primary methods for measuring completed work items. The **percentage complete
method** rests upon periodic estimates of the percentage of work completed on a work item basis. For
example, a monthly payment application may estimate backfill work 50% complete, underground
conduit 32%, etc. The **physical units of work completed method**, however, is more detailed and
more accurate. Under this method, the actual units of work are surveyed for completion on a
regular or periodic basis and compared to the total known number of units to be installed or
constructed. Any of the project specific studies below can use either of these calculations, depending
upon contemporaneous project documentation maintained by field personnel.

- **Measured Mile Study** – According to Schwartzkopf --

“The most widely accepted method of calculating lost labor productivity is known throughout the
industry as the “Measured Mile” calculation. This calculation compares identical activities in
impacted and non-impacted sections of the project in order to ascertain the loss of productivity
resulting from the impact of a known set of events. The Measured Mile calculation is favored
because it considers only the actual effect of the alleged impact and thereby eliminates disputes
over the validity of cost estimates, or factors that may have impacted productivity due to no fault
of the owner.”

A recent court decision has broadened the Measured Mile calculation to include comparison of
similar work activities and least impacted periods versus impacted periods. If sufficient work on
the project is complete in an unimpacted or least impacted period and the quantity of work is
known then calculations can usually be performed to ascertain a baseline level of productivity for
that part of the work. Physical units of work complete divided by hours expended to complete
these work items determines productivity during the least impacted or unimpacted period. A
similar calculation is then performed for the period of the impact. The productivity loss can then
be calculated by subtracting the unit productivity rate during the impacted period from the unit
productivity during the unimpacted period. It is noted that when performing a Measured Mile
calculation, other variables, which could affect productivity but are unrelated to the claimed
impacts, must be accounted for and removed from the impacted period calculation to the extent
these variables occurred during the least or unimpacted period. These may include weather,
project mismanagement, subcontractor-related problems, voluntary acceleration, etc.

Numerous federal court cases have upheld use of the measured mile technique including E.C.
Ernst, Inc. v. Koopers Company, Natkin & Company v. George A. Fuller Company, United
States Industries, Inc. v. Blake Construction Company, Inc., Appeal of Batteast Company,
Goodwin Contractors, Inc., and Clark Concrete Contractors, Inc. v. General Services
Administration. Of the four methodologies listed in the project specific studies category the
Measured Mile study is the method most often cited in court cases. It is probably the best of the
recommended practices, assuming there is sufficient contemporaneous data to allow such an
approach. This method appears to be recognized as the most credible in the legal system.
Additionally, unlike some other methods, the Measured Mile study can be used after the impact
has occurred or as a sampling technique, while the impacted work is in progress.
• **Earned Value Analysis** – Productivity measurement is sometimes difficult when there is insufficient information concerning the physical units of work installed on the project. In these situations, a simplistic form of the earned value analysis method can be utilized to calculate estimated labor hours. The contractor’s estimate or alternatively the dollar value of payment applications, contract amounts or unit prices can be used to determine labor hours, when they were expended and, possibly, on what activities. Physical units of work completed multiplied by budget unit rates can be used to determine earned hours. The earned hours are then compared to the actual hours expended for the period of the impact and the difference between the two may be used to calculate the productivity loss experienced. Earned value measurement of contemporaneous project documentation, such as percentages complete from schedule updates or payment applications can assist with calculating labor productivity. Additionally, the claimant may calculate the actual revenue per hour of labor versus the planned revenue per hour, as an alternative. Earned value analysis may also be utilized to calculate estimated labor hours. When using the earned value analysis technique, it is cautioned that the budget used to generate the earned value metrics be carefully reviewed and verified for reasonableness. Any earned value analysis based upon an unreasonable budget is highly suspect. Finally, it is noted that a fully resource loaded (labor and quantities) CPM schedule is a good source for obtaining earned value metrics and allows for like-time causation analysis.

• **Work Sampling Method** – Work sampling is a method in which the claims analyst makes a large number of direct observations of craftsmen to determine what they are doing at various points in time. Work sampling is defined as

> “An application of random sampling techniques to the study of work activities so that the proportions of time devoted to different elements of work can be estimated with a given degree of statistical validity.”

From these observations the claimant determines, on a percentage basis, how much time is spent between direct work (pay item work); support work (moving tools and materials to the work location); or delays (time when no work is being performed). By performing a number of work sampling studies, the analyst can draw comparisons of productivity before and after known events, between work activities or crews, etc. Work sampling has been offered as a means of determining productivity loss but it can only be performed during the life of the project and is not compatible with a hindsight analysis effort.

• **Craftsmen Questionnaire Sampling Method** – Claims analysts estimating lost productivity frequently are not in the field, on the project, during the disruption period. However, when productivity loss is recognized by field project management staff, a questionnaire can be prepared and provided to craftsmen in the field. The questionnaire allows craftsmen to estimate the amount of lost productive time in the field on a daily or weekly basis, identifying the reason for the lost time. While, perhaps, not the most scientific of studies, this is contemporaneous documentation if administered properly. The claimant can then tie the results of such a survey to the entitlement and causation arguments. A variation of this method is the use of a Craftsmen Questionnaire at the end of the job, to confirm or modify a productivity loss analysis performed utilizing another method. For example, a recent Board of Contract Appeals case allowed a Craftsmen Questionnaire to be used as a modifier of an industry-wide study and awarded lost productivity costs to a mechanical subcontractor on this basis.

➢ **Project Comparison Studies** – There may be times when a claimant needs to prepare an estimate of lost productivity when circumstances affecting productivity such as project change, delay or disruption ran throughout the entire project. That is, the circumstances of the project were such that there were no unimpacted periods for the work activity in question from which one can determine baseline productivity. In these circumstances, and assuming it is possible, recommended practice is to utilize one of the following methods, assuming sufficient data exists.
• **Comparable Work Study** – There are two forms of this analytical technique. One form is for the contractor to estimate productivity loss on the impacted portion of the project. Once done, the analyst locates an analogous or similar work activity on the project, which was unimpacted (or least impacted) and calculates the productivity on this work. For example, a comparison of electrical conduit installation with fire sprinkler installation. The ratio of the two calculations then forms the estimated productivity loss. The difficulty in this method is determining what is analogous or similar work? If the productivity loss occurred during the installation of electrical conduit, is such work really analogous to installation of fire sprinkler piping? Factors such as size, length, weight, height above ground or off the deck, etc. must all be carefully considered and documented to successfully present such an analysis. The other form of a comparable work study is to calculate productivity during the impacted period on the project and compare this productivity to similar work, on the same project, performed by another contractor whose work was not impacted. Typically, the comparable work study is only performed when study of the same work before and after a known event is not possible and thus a measured mile analysis cannot be completed. Perhaps change orders concerning the electrical conduit were so pervasive from the outset of the work that the contractor was never able to achieve a measured mile plateau. In such situations, project owners are unlikely to allow a comparison of actual productivity with as-bid productivity, even if they are responsible for the changes. So, in its place, the contractor may be able to compare actual productivity on conduit installation with productivity on fire sprinkler installation to draw some conclusions.

• **Comparable Project Study** – In the event that the comparable work study cannot be performed, an acceptable alternative may be to calculate productivity on the project in dispute and compare this productivity to that achieved on another project with similar work. Of course, to do this successfully the contractor must demonstrate that the comparable project was of similar size and magnitude, similar location, similar weather and labor conditions, etc. The more similarity between the projects, the more likely it is that this method will be given credence. Less similarity between projects obviously leads to decreased chances of success.

➢ **Specialty Industry Studies** – In the event there is insufficient contemporaneous project documentation to allow preparation of one of the project specific or project comparison studies set forth above, or other circumstances dictate, recommended practice is to perform a productivity loss estimate using data developed by one of the specialized studies listed below. The claimant will, of course, be challenged to demonstrate entitlement and causation, as mentioned previously. Additionally, the contractor will have to demonstrate that the project encountered a situation similar to that of the specialized study or studies relied upon. The primary distinctions between the specialty industry studies listed below and the general industry studies listed in the next section are that (1) these studies are subject specific; (2) are often limited to a specific industry; and, (3) are generally based upon a small number of specific projects rather than a generalized survey of the industry nationwide.

• **Acceleration** – These papers and studies offer observations on assessment of productivity impacts when a project is accelerated – sped up or required to perform work in less time than otherwise allowed. The studies look into such issues as trade stacking, crew overmanning and manning levels, that result from such a situation, among other things. See Appendix A for a list of studies and papers related to this topic.

• **Changes, Cumulative Impact and Rework** – These studies and papers offer an assessment of productivity impact when there are a large number of changes during performance of the work on a project. Additionally, some of these specialized studies look specifically at the issues of the cumulative (synergistic) impact of multiple changes. Also listed are a few studies addressing the issue of “What is the normal amount of change to be expected on a project?” See Appendix B for a list of papers and studies related to this topic.
Learning Curve – Learning curve is the typical productivity encountered at the beginning of any project or any major project activity. Craft labor has to get used to working as a crew. They must learn the site and its layout (i.e., where the washrooms and tool cribs are located, where the laydown areas are, etc.) Crews must also acclimate to project requirements (level of quality required, level of inspection imposed, production output required to meet schedule requirements, etc.). Learning curve is typical. Learning curve may also occur later in projects if work is suspended and labor demobilized and later remobilized. These papers and studies look at productivity impact when a project encounters a delay or suspension of work causing craft to be removed from the site and later remobilized. See Appendix C for a list of studies and papers related to this topic.

Overtime and Shift Work – These studies and papers consider productivity impact when there is a good deal of work on an overtime or shift work basis on a project over a lengthy period of time. See Appendix D for a list of papers and studies related to this topic.

Project Characteristics – These papers and studies observe productivity impact related to differing project characteristics. See Appendix E for a list of studies and papers related to this topic.

Project Management – These studies and papers review productivity impact resulting from project mismanagement including engineering impacts, lack of construction equipment, tools and materials, management turnover at the site, etc. See Appendix F for a list of papers and studies related to this topic.

Weather – These papers and studies assess labor productivity impact caused by weather conditions. See Appendix G for a list of studies and papers related to this topic.

General Industry Studies – Sometimes there is insufficient contemporaneous documentation to support a project specific study or a project comparison study, and further, the loss of productivity stemmed from numerous, non-specific causes. This is especially true when there is a lack of contemporaneous data from a project or when there is a surfeit of non-definitive data. In these situations then, recommended practice is to employ one of the general industry studies listed below. Caution must be exercised in using these studies for a number of generally well known reasons. Among these are the following.

- The source data for the factors listed in these studies is not always known. The data may be from a survey and comprised of anecdotal information as opposed to empirical data.44
- These studies do not address how to apply these factors in situations where multiple causes of productivity loss have been identified during the entitlement and causation analysis.45
- These studies do not address whether the factors are to be applied to the entire project, portions of the project, the changed work, etc.46
- These studies are rarely conclusive concerning quantification of productivity loss because they bear no direct relationship to the project in dispute.47
- These studies are perceived, by some, as being self-serving studies because they appear to serve the best interests of contractors from the industry association that prepared the studies.48
- These studies can be used to attack the reasonableness of the contractor’s planned productivity ratios.49
Courts and Board of Contract Appeals seem to be more willing to accept these studies as support or rebuttal evidence rather than direct evidence of productivity loss.\(^{50}\)

Finally, it is noted, these industry studies were initially prepared for estimating and forward pricing of change order or extra work order purposes and not for hindsight analysis of lost productivity estimates.\(^{51}\)

Having made the above statements, Courts and Boards of Contract Appeals continue to allow the use of general industry studies under the proper circumstances. If the contractor can demonstrate causation and entitlement and, that there is no better method to estimate the resulting damages, then Court and Boards may allow use of these studies.\(^{52}\)

The three most commonly referred to general industry studies are the following.


- **U.S. Army Corps of Engineers, Modification Impact Evaluation Guide,** EP 415-1-3, Department of the Army, Office of the Chief of Engineers, Washington, D.C., July, 1979.\(^{53}\) This manual addressed a number of factors the Corps was willing to discuss and negotiate when considering the forward pricing of change orders.

Despite the identified and well-known weaknesses with these general industry studies they remain recommended practice under proper circumstances. First, the claimant must demonstrate entitlement and causation. Then, there must be a showing that there is no better information upon which to estimate resulting damages. Finally, the contractor must show that the impacts encountered on the project rationally fit one or more of these studies.

Additionally, there is another type of general industry study, which is available for the claim analyst to utilize. National estimating guides are classified in this Recommended Practice as general industry studies because the information and data contained therein is based upon studies of the construction industry in general. They are not, usually, as subject to the criticisms listed above. However, the claimant will still be challenged to demonstrate entitlement and causation and prove that there is no better way to estimate the resulting damages. If this can be done, estimating guides may be utilized and may be given some credence. The national estimating guides on the market generally are updated annually or, perhaps, even more frequently. These guides often provide productivity information. Unlike the general industry studies listed above (which list percentage factors to calculate productivity loss under certain situations) the estimating guides are useful to establish the norm or the baseline productivity the contractor should have been able to achieve but for the events encountered. Thus, an estimated Measured Mile approach can be constructed by calculating actual productivity on the project and comparing it to an estimated productivity from one or more of the estimating guides. See Appendix H for a list of estimating guides available for such use.

**Cost Basis** – If it is possible to demonstrate entitlement and causation but there is insufficient project documentation to support damage calculations using any of the above techniques, recommended practice is to use one of the costing methods set forth below. These methods require analysis of the
project job cost records. The purpose of such preliminary analysis is to determine actual direct labor hours and costs (having stripped out materials, installed equipment, supplies, field and home office overhead, small tools and consumables, etc.).

- **Total Unit Cost Method** – This method is a variation of the Total Labor Cost Method discussed below. Under this method, all costs incurred (labor, material, equipment, subcontractors, small tools and consumables, etc.) are divided by the units of work completed during that period of time. A similar calculation is made for units of work in a different period of time. Assuming no other variables arose during the second period of time then it can be posited that the difference in unit cost is the impact of the event identified by the claimant. Calculations then have to be made to determine and remove the costs of materials, equipment, small tools and subcontract costs. Once done, the remainder is all labor cost and the differential in labor cost per unit installed is, arguably, the labor productivity impact resulting from the event complained of.  

- **Modified Total Labor Cost Method** – This method is the same as the Total Labor Cost Method, except that the contractor subtracts out known bid errors, excessive costs (i.e., the failure to mitigate damages), field problems for which the contractor was responsible, etc.. As a result, the formula is as follows.

\[
\text{Total Labor Cost Owed} = \text{Total Labor Cost Expended} - \text{Acknowledged Contractor Problems} - \text{Total Labor Cost Paid}
\]

The contractor using this recommended practice is still faced with overcoming the challenge of the four-part test set forth by the courts noted below. It is imprudent to use this method when a more credible method is possible. However, by subtracting contractor problems from the cost equation, the contractor addresses the last three tests in an affirmative manner. Similarly, a contractor who corrects “busts” either in their bid or their budget will, at least in part, address the second, third and fourth tests outlined below.

- **Total Labor Cost Method** – The basic formula for a total labor cost analysis is the following.

\[
\text{Total Labor Cost Owed} = \text{Total Labor Cost Expended} - \text{Total Labor Cost Paid}
\]

This method of estimating damages may be applied to the entire project, if the loss of productivity extended to all work. In the alternative, this estimating technique may be applied to a particular area of the work (i.e., glazing, masonry, etc.) if only specific areas or items of work were impacted. It may also be applied only to certain craft labor crews if it can be shown that only certain crews were subject to the loss of productivity. It is, however, the least accepted method to calculate decreased labor productivity.

When using a cost basis methodology, the contractor must remember that labor costs are a function of both the number of manhours and the unit cost of these hours. Thus, the total labor cost expended may exceed the total labor cost paid due to an increase in the average unit cost of labor not a loss of productivity (i.e., more hours expended than planned). While many of the factors that impact productivity may also increase the unit cost of labor, there may be other circumstances on the project that increase the unit cost of labor (i.e., a union requiring a different mix of apprentices to journeymen) that are unrelated to those affecting productivity. Thus, it is recommended practice that the claimant separately address both productivity losses (i.e., increase in hours) and differences in unit cost of labor, when utilizing a cost basis method.

In utilizing this recommended practice, claimants must also be cognizant that a number of legal hurdles must be overcome if one is to be successful in using this approach in litigation. In order to safeguard against the potential inequities embodied in the above formula, courts have set up a standard four-part test. To use this method of pricing damages, the contractor must demonstrate the following.
1. The nature of the particular losses make it impracticable, if not impossible, to determine damages in any other more particular manner.

2. The contractor’s bid or estimate was reasonable and free of any material errors.

3. The contractor’s actual costs were reasonable (meaning that the claimant has the challenge of proving mitigation of damages).

4. The contractor was not responsible for any of the events leading to the loss of productivity.\(^{57}\)

Assuming that the contractor can overcome these four tests, this recommended practice is an allowable method for estimating lost productivity damages.

**Productivity Impact on Schedule** – It is not within the scope of this Recommended Practice to discuss scheduling and scheduling techniques. However, there is a relationship between a lost labor productivity analysis, lost labor productivity’s impact to a project schedule and, possibly, the critical path of that schedule. It is recognized that schedule delay may not only result from productivity loss, but in many cases, may precede the productivity loss. The factor that often drives a contractor to perform work inefficiently is the lack of time to perform the work more efficiently. As a result, there is very little loss of productivity that does not involve some element of delay followed by attempted or actual acceleration somewhere in its chain of causation. Therefore, schedule analysis often plays a major role in analyzing entitlement and, perhaps, impact of productivity loss.

In general terms the relationship between labor productivity and schedule impact is often as follows: If a contractor encounters productivity loss at some point during the progress of the work, then those activities, which are less productive, will tend to stretch out in duration. This, in turn, may impact other activities. For example, follow on activities may also have increased durations; may have to be resequenced in order to meet schedule end dates; or may be pushed from good weather or lower wage rate points in time into bad weather or periods of higher wages. It has been acknowledged by the Courts that, “…the contractor does not need to prove that contract performance was extended beyond the planned completion date in order to recover for lost productivity.”\(^{58}\) However, if planned work activities have been resequenced or moved from good to bad weather periods, it is likely that they too, will have suffered a loss of productivity. This can be the synergistic or ripple effect of productivity loss on otherwise unchanged work. The challenge then is for the claimant to determine such ripple impact, show entitlement, demonstrate the cause and effect relationship and then, estimate or document damages suffered.

There is no industry-wide agreement on what scheduling technique should be applied when analyzing delay and impact. And, as noted above, it is not the intent of this Recommended Practice to facilitate such an agreement. This Recommended Practice addresses the issue of how to estimate and price lost labor productivity. It is noted that a separate Recommended Practice for Schedule Delay Analysis is under preparation at the time of this writing.

### Schedule Impact Analysis

- **Schedule Impact Analysis** – Recommended practice in this regard is to utilize some schedule analysis technique to determine overall project delay or delay to some activities within the schedule. Once a determination is made that some or all of the remaining activities on the schedule were delayed then the above techniques can be applied to determine whether any productivity loss grew out of such delay. Delayed activities are identified and recalculated\(^{59}\) to estimate the effect of such delay in terms of productivity loss. Other activities must then be analyzed to determine whether they too suffered from productivity impacts. If so, then these activities may also have to be recalculated and the schedule analysis run yet again. This is an iterative process, which continues until all activities downstream of the initial productivity loss have been examined to determine whether they were affected by ripple impact. Once this
process is completed then damages may be calculated using one or more of the recommended practices identified above.

D. CONCLUSION

Under appropriate fact circumstances, all of the methods set forth herein are technically acceptable which is why they have been included in this Recommended Practice. Of all the methods identified above, the most reliable are those set forth in the section on Project Specific Studies. These methods are based upon contemporaneous documentation and knowledge from the project. Thus, they come the closest to approximating actual damages from a project. All other methodologies discussed in this Recommended Practice are estimating techniques with varying degrees of reliability. Therefore, they are considered somewhat less reliable that the Project Specific Studies. This again highlights the importance of keeping good project records from the outset of the project which captures contemporaneous project documentation by individuals actively involved in constructing the project.

E. TERMS & DEFINITIONS

The terms and definitions included herein are taken from AACE International’s Recommended Practice No. 10S-90 “Cost Engineering Terminology”.

BUDGET - a planned allocation of resources. The planned cost of needed materials is usually subdivided into quantity required and unit cost. The planned cost of labor is usually subdivided into the workhours required and the wage rate (plus fringe benefits and taxes). (11/90)

CASH FLOW - the net flow of dollars into or out of a project. The algebraic sum, in any time period, of all cash receipts, expenses, and investments. Also called cash proceeds or cash generated. The stream of monetary (dollar) values -- costs and benefits -- resulting from a project investment. [A] (11/90)

COST - in project control and accounting, it is the amount measured in money, cash expended or liability incurred, in consideration of goods and/or services received. From a total cost management perspective, cost may include any investment of resources in strategic assets including time, monetary, human, and physical resources. (1/02)

DELAY - to cause the work or some portion of the work to start or be completed later than planned or later than scheduled.

DIRECT COST - (1) in construction, cost of installed equipment, material and labor directly involved in the physical construction of the permanent facility.

Although the direct costs described above are typical and in general use, each industry has unique costs which fall into the “direct cost” category. A few examples are equipment rental, waste disposal, contracts, etc. (11/90)

DISRUPTION - an action or event which hinders a party from proceeding with the work or some portion of the work as planned or as scheduled.

EARNED VALUE - the periodic, consistent measurement of work performed in terms of the budget planned for that work. In criteria terminology, earned value is the budgeted cost of work performed. It is compared to the budgeted cost of work scheduled (planned) to obtain schedule performance and it is compared to the actual cost of work performed to obtain cost performance. (11/90)

EFFICIENCY - the ratio of the effective or useful output to the total input in a project.
IMPACT COST - added expenses due to the indirect results of a changed condition, delay, or changes that are a consequence of the initial event. Examples of these costs are premium time, lost efficiency, and extended field and home office overhead.

INDIRECT COSTS - (1) in construction, all costs which do not become a final part of the installation, but which are required for the orderly completion of the installation and may include, but are not limited to, field administration, direct supervision, capital tools, startup costs, contractor's fees, insurance, taxes, etc. (11/90)

INEFFICIENCY - level of production or performance that is less than that which could have been achieved under as-planned normal working conditions. Some of the causes that may lead to inefficient performance are changes, delays, and differing site conditions.

LOST PRODUCTIVITY - see INEFFICIENCY.

PRODUCTION RATE - the amount of work, which may be accomplished in a given unit of time.

PRODUCTIVITY - In general terms, labor productivity can be defined as the ratio of the value that labor produces to the value invested in labor. It is an absolute measure of work process efficiency, i.e., a measure of the extent to which labor resources are minimized and wasted effort is eliminated from the work process.

In earned value project control practice, productivity is a relative measure of labor efficiency, either good or bad, when compared to an established base or norm as determined from an area of great experience. Alternatively, productivity is defined as the reciprocal of the labor factor. (1/04)

RIPPLE EFFECT - the multiplying effect of change(s) and/or productivity impacts to upstream work that may have an adverse impact on the subsequent work to be performed.

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APPENDIX A: Specialized Studies Related to Acceleration

APPENDIX B: Specialized Studies Related to Changes, Cumulative Impact and Rework

- Construction Industry Institute, The Impact of Changes on Construction Cost and Schedule, CII Research Summary RS6-10, Austin, Texas, April 1990.
- Construction Industry Institute, Quantitative Effects of Project Change Executive Summary, CII Research Summary RS43-2, Austin, Texas, December 1994.
- Construction Industry Institute, Quantifying the Cumulative Impact of Change Orders for Electrical and Mechanical Contractors, Research Summary 158-1, Austin, Texas, 2001.
APPENDIX C: Specialized Studies Related to Learning Curve

APPENDIX D: Specialized Studies Related to Overtime and Shift Work

- Haverton, John, *Do You Know the Hidden Costs of Overtime?*, Qualified Contractor, 1969.
APPENDIX E: Specialized Studies Related to Project Characteristics

APPENDIX F: Specialized Studies Related to Project Management Factors

APPENDIX G: Specialized Studies Related to Weather

APPENDIX H: Estimating Guides

END NOTES

16 See Jones and Driscoll, ibid, page A-5.
19 Schwartzkopf, *ibid*, §1.03[B].
20 See Schwartzkopf, *Calculating Lost Labor Productivity in Construction*, *ibid*, §1.3.
21 See Schwartzkopf, *Calculating Lost Labor Productivity in Construction*, *ibid*, §2.09[A] and §10.4.


25 347 F. Supp. 17 (W.D. Mo. 1972), reconsidered, 626 F.2d 324 (8th Cir. 1980).

26 671 F.2d 539 (D.C. Cir. 1982).


28 AGBCA No. 89-148-1, 92-2 BCA (CCH) ¶24,931 (1992).

29 GSBCA No. 14340, 99-1 BCA (CCH) ¶30,280 (1999).


34 See Fleming, Quentin W. and Joel M. Koppelman, Earned Value Project Management, Project Management Institute, Upper Darby, PA. 1996.


36 See Jones and Driscoll, ibid, page B-24.


41 See Robert McMullen & Sons, Inc., ASBCA No. 19,929, 76-2 BCA (CCH) ¶12,072 (1976).

42 See Schwartzkopf and McNamara, Calculating Construction Damages, ibid, §2.09[B].

43 It should be noted that this is not an all-inclusive list of specialized studies. As others are identified, this Recommended Practice will be modified, from time to time, to include them. It is also further noted that some of the studies listed herein have incomplete references as full information is not available at the time of publication of this Recommended Practice.

44 See Schwartzkopf, Calculating Lost Labor Productivity in Construction Claims, ibid, §11.2 & 11.3

45 Ibid.

46 Ibid.

47 See Schwartzkopf and McNamara, Calculating Construction Damages, ibid, §2.09[C].

48 Ibid.

49 Ibid.

50 Ibid.

51 See Schwartzkopf, Calculating Lost Labor Productivity in Construction Claims, ibid, §11.2& 11.3.

52 See Jones and Driscoll, Cumulative Impact Claims, ibid, Page A-36. See also Clark Concrete Contractors, Inc. v. General Services Administration, GSBCA No. 14340, 99-1 BCA (CCH) ¶30,280,

It should be noted that although the Corps of Engineers officially recognized this Guide as a valid means to assess claims for more than twenty years, on June 14, 1996 the Corps of Engineers officially rescinded the Modification Impact Evaluation Guide by issuance of Circular No. 25-1-244. At that time, the Corps claimed that the Guide “has been updated and is incorporated in other publications to include higher level regulations, training course materials and other command guidance.” See Mark G. Jackson, Carl W. LaFraugh and Robert P. Majerus, Using Industry Studies to Quantify Lost Productivity, Construction Briefings, Federal Publications, Washington, D.C., December, 2001. See also, Jones, Reginald M. and Thomas J. Driscoll, Cumulative Impact Claims, Federal Publications Seminars, LLC., Washington, D.C., 2002, page A-38.


“Total Labor Cost Paid” = Labor cost in base bid + labor cost paid in change orders and previous claim settlements.

See Schwartzkopf and McNamara, Calculating Construction Damages, ibid, §2.09[E]

See Schwartzkopf and McNamara, Calculating Construction Damages, ibid, §1.03[C] and [D] and cases cited therein. See also, Jones and Driscoll, ibid, pp. A-31 through A-35 and cases cited therein. See also, Wickwire, Driscoll, Hurlbutt and Hillman, Construction Scheduling: Preparation, Liability and Claims, ibid, §12.05 and cases cited therein.

See Sauer, Inc. v, Danzig, 224F.3d 1340, 1348 (Fed. Cir. 2000).

In this context, the term “recalculate” is used to indicate changes to the previously identified and defined schedule activity. This may include, but is not limited to, increased duration, resequencing, changes to planned resources, etc.

The R.S. Means Company has been purchased by Reed Construction Data. At present, these estimating manuals are still being marketed under the R.S. Means name but this may change.

Ibid.