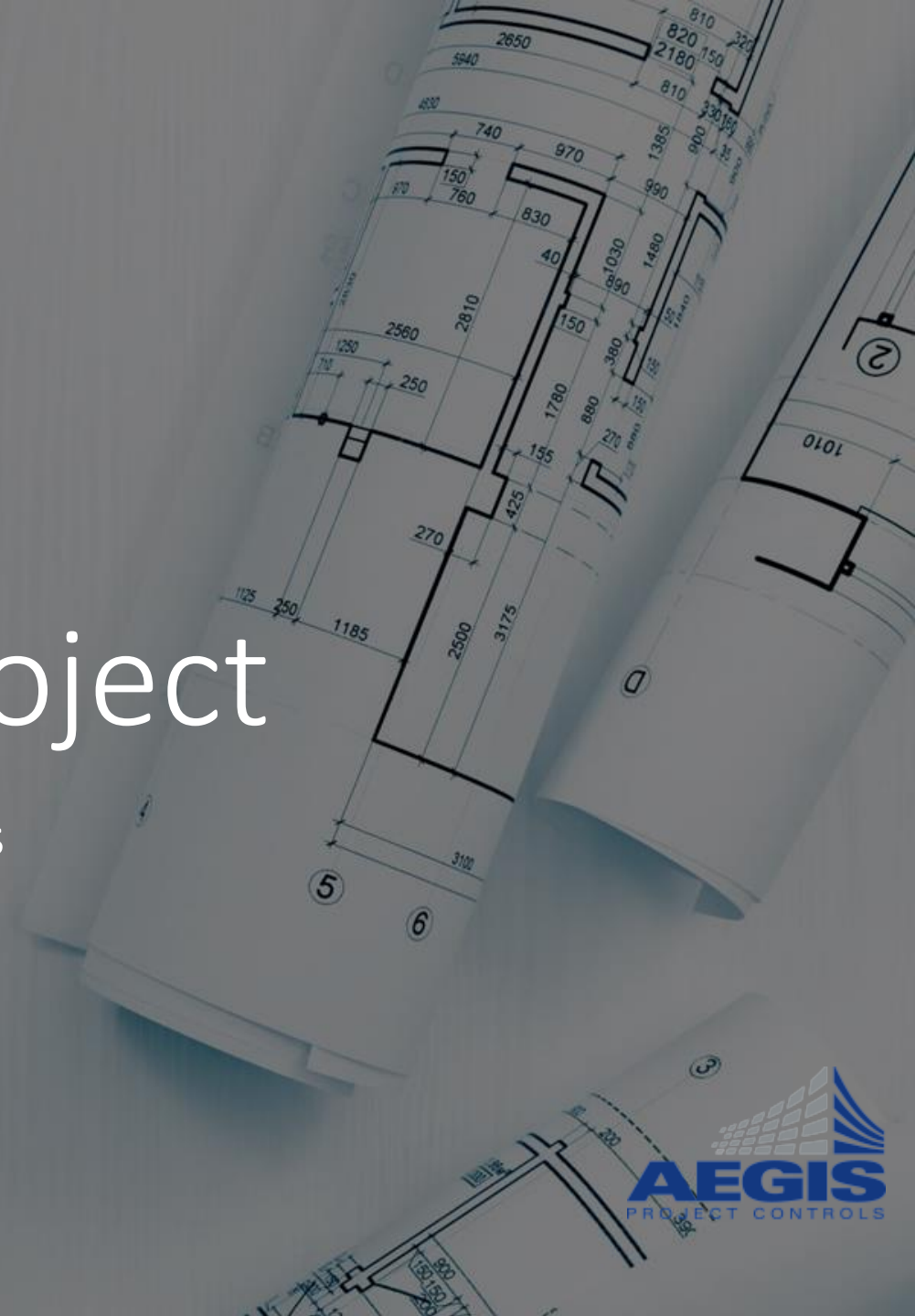
Planning a Project

Aegis Project Controls



Critical Path Method Scheduling

- Critical Path Method (CPM) is the most widely used scheduling technique and is often referred to as critical path scheduling. This scheduling technique used to plan and manage a project and calculates the minimum completion time for a project along with the possible start and finish times for the project activities.

- A schedule is a formal, approved document used to guide both project execution and project control. The primary uses of the project plan are to document planning assumptions and decisions, facilitate communication among stakeholders, and document approved scope, cost, and schedule baselines. A project plan may be summarized or detailed.

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Purpose of a schedule

What? A road map for project execution but also the means by which to gauge progress, identify and resolve potential problems, and promote accountability at all levels of the program

Why? Scheduling allows the team to decide between possible sequences of activities, determine the flexibility of the schedule, predict the consequences of events, and allocate contingency plans to mitigate risk

Who? All stakeholders involved in the project

When? When required by contract, as well as when the team is anticipating a complex or challenging projects

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Elements of a Logical Schedule

Scheduling all of your Activities

Work Breadown Structure vs. Activity Codes

Activity ID’s

Activity Names

Calendars

Capturing Logic in the Schedule

Leads and Lags

Early and Late Dates

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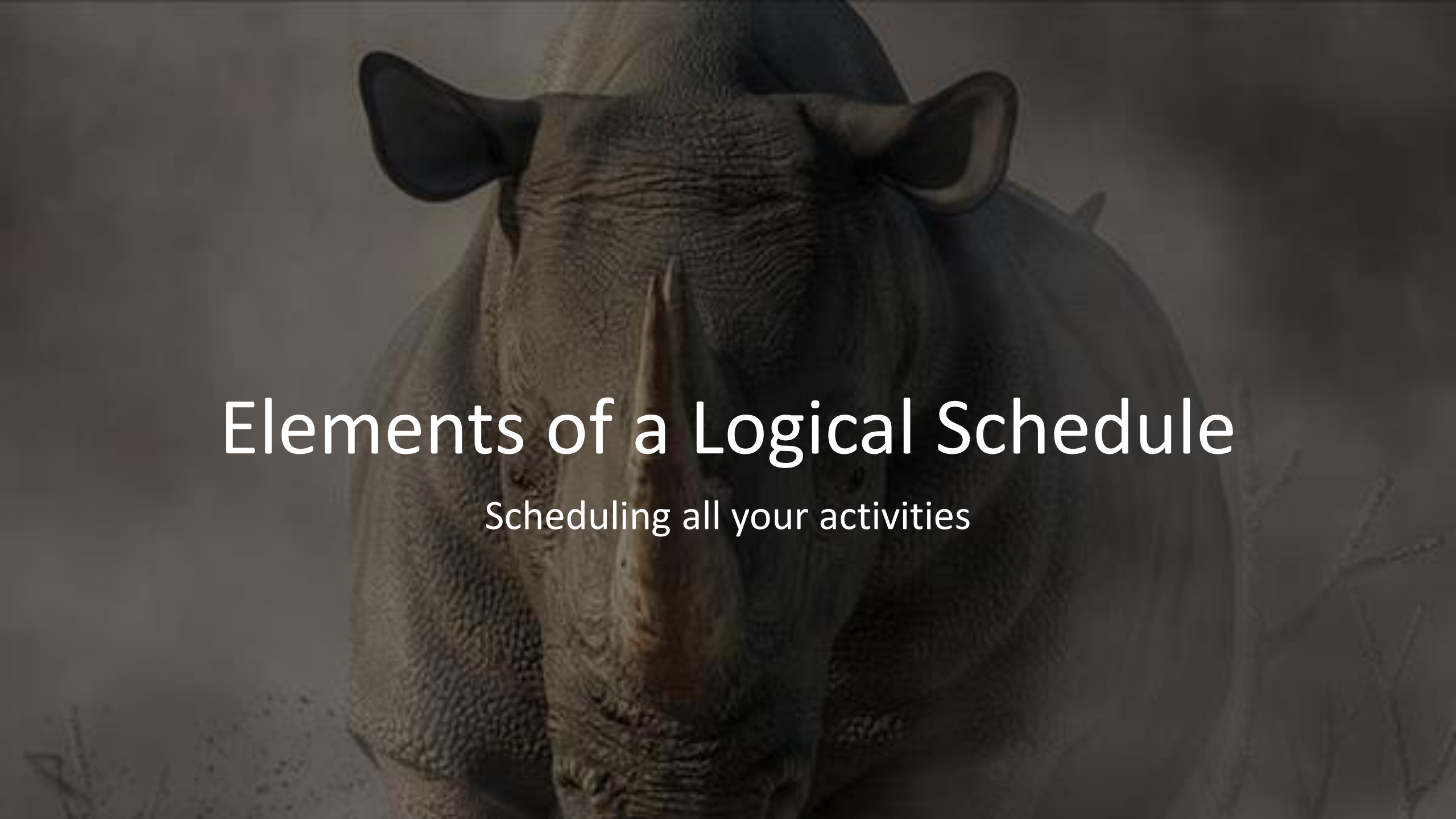

Elements of a Logical Schedule

Scheduling all your activities

Scheduling all your Activities

A subcontractor project schedule, is a subset of the schedule, and includes only contractually authorized work.

Subcontractors are obligated to plan activities required by, and limited to, the contract.

This will tie into one comprehensive schedule that can be used to reliably forecast key Project dates.

Scheduling all your Activities

The schedule should reflect all effort necessary to successfully complete your scope of work

Failing to include all work for all deliverables can inhibit your team's understanding of the plan completely and the if the project is progressing toward a successful completion

If activities are missing from the schedule, then other best practices will not be met.

If all activities are not accounted for, we can't be certain whether the activities are in the correct order, resources are allocated, the critical path is valid, or a schedule risk analysis will account for all risk.

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Scheduling all your Activities

Activities represent the performance of actual discrete work that is planned in the Project

They are measurable portions of effort that result in a discrete product or component

They are logically linked to other preceding and succeeding activities to form logical sequences and parallel paths of work that must be accomplished to complete the Project

Logically related paths of detail activities are linked to milestones to show the progression of work that is planned.

Activities have an estimated duration; that is, a planned estimate of the time it will take to complete the work

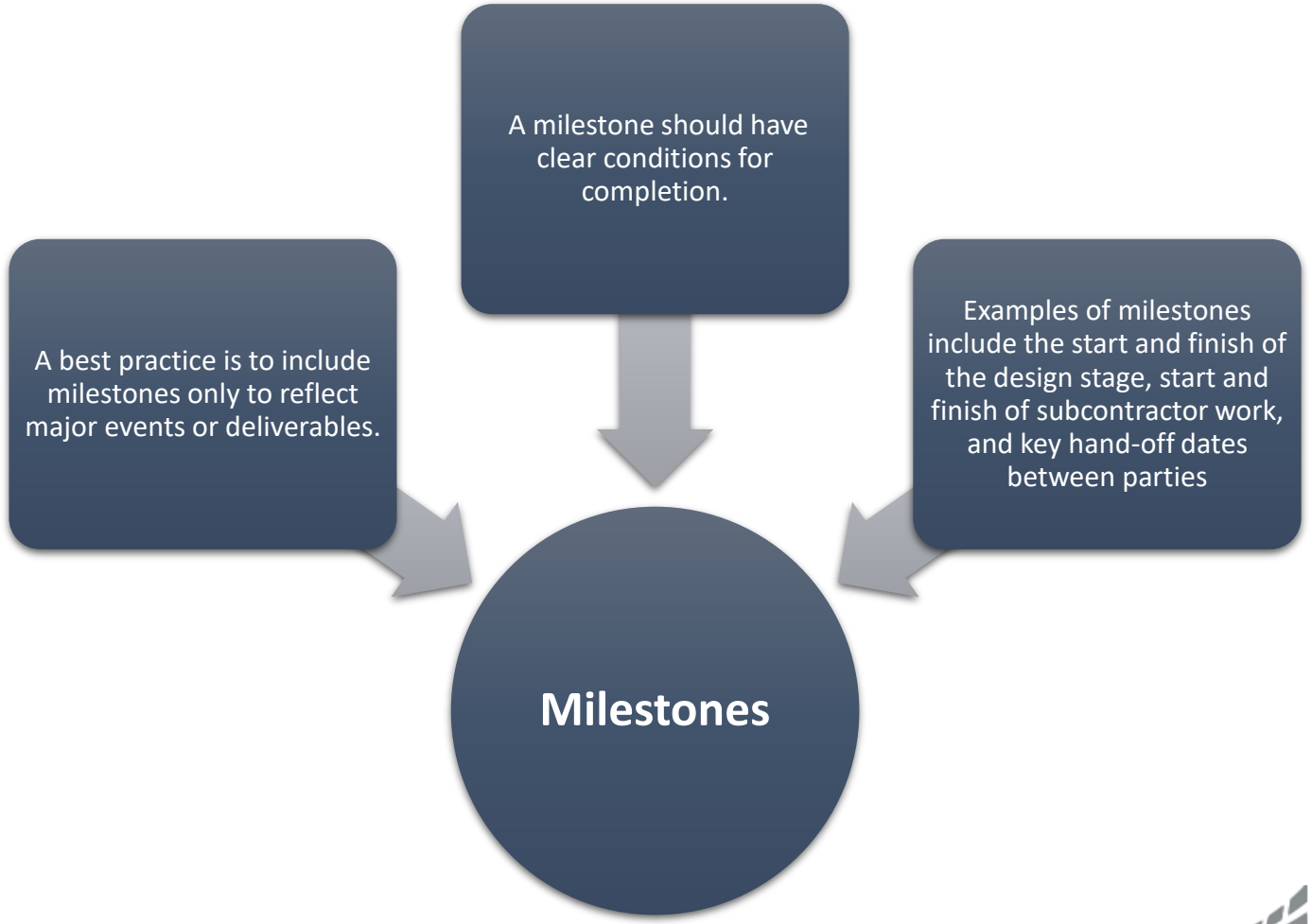
Scheduling all your Activities

Because the schedule is used for coordination, missing activities will impede coordination, increasing the likelihood of disruption and delay.

A comprehensive schedule should reflect all of a subcontractor’s activities.

Recognize that uncertainties and unknown factors in schedule estimates can stem from, among other things, missing information

Scheduling all your Activities



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Scheduling all your Activities

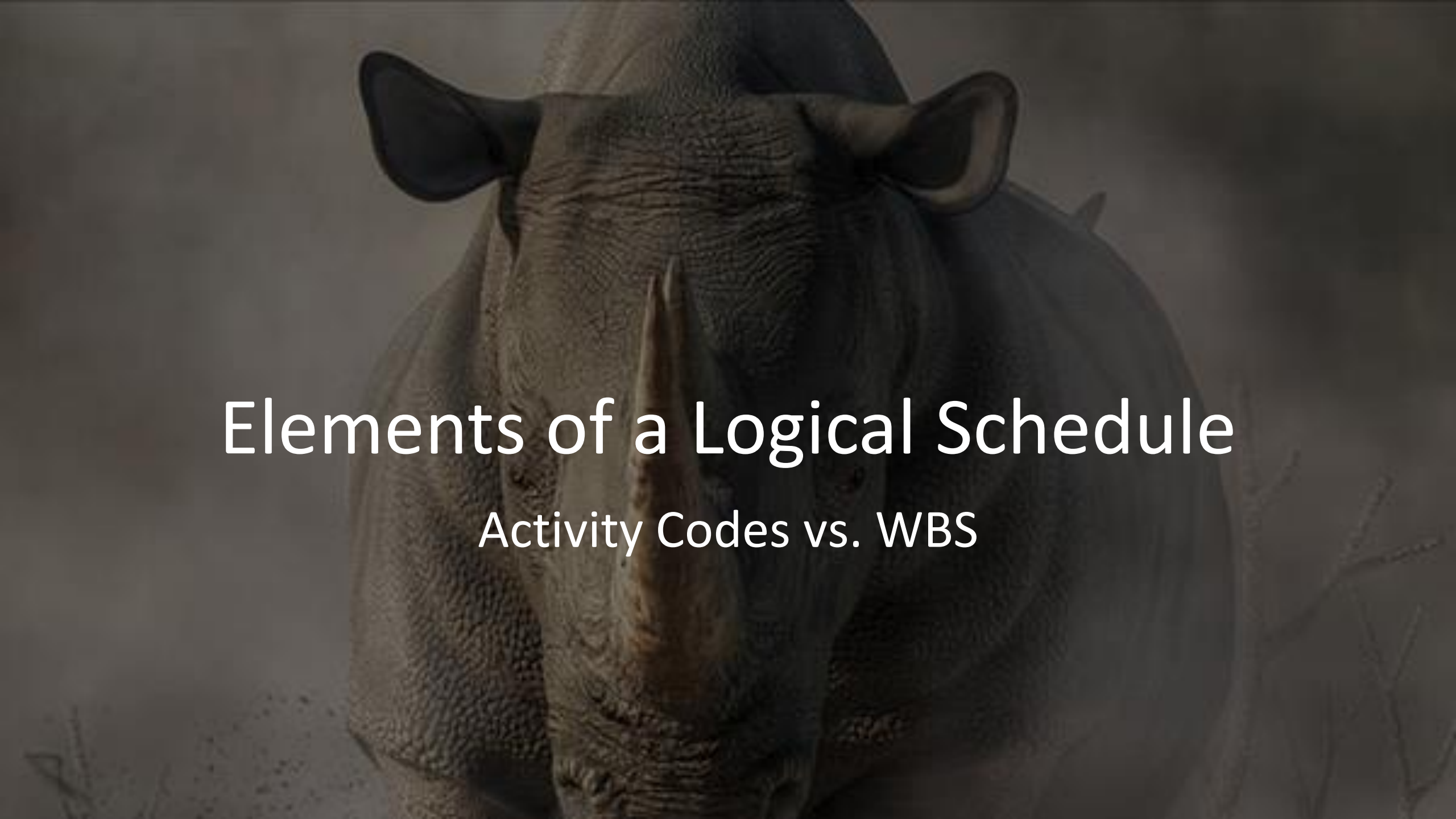
The level of detail in the schedule should reflect the level of information available on the portion of the work that is planned to be accomplished.

The subcontractor must define the effort required to complete the project in a way that fully details the entire scope and planned flow of the work.

In this manner, the schedule is defined to the level necessary for executing daily work and regularly updating the Project.

Schedules that are defined at too high a level may disguise risk that is inherent in lower-level activities.

In contrast, too much detail in a schedule will make it difficult to manage progress and may convolute the calculation of critical paths.



Elements of a Logical Schedule

Activity Codes vs. WBS

Activity Codes vs. WBS

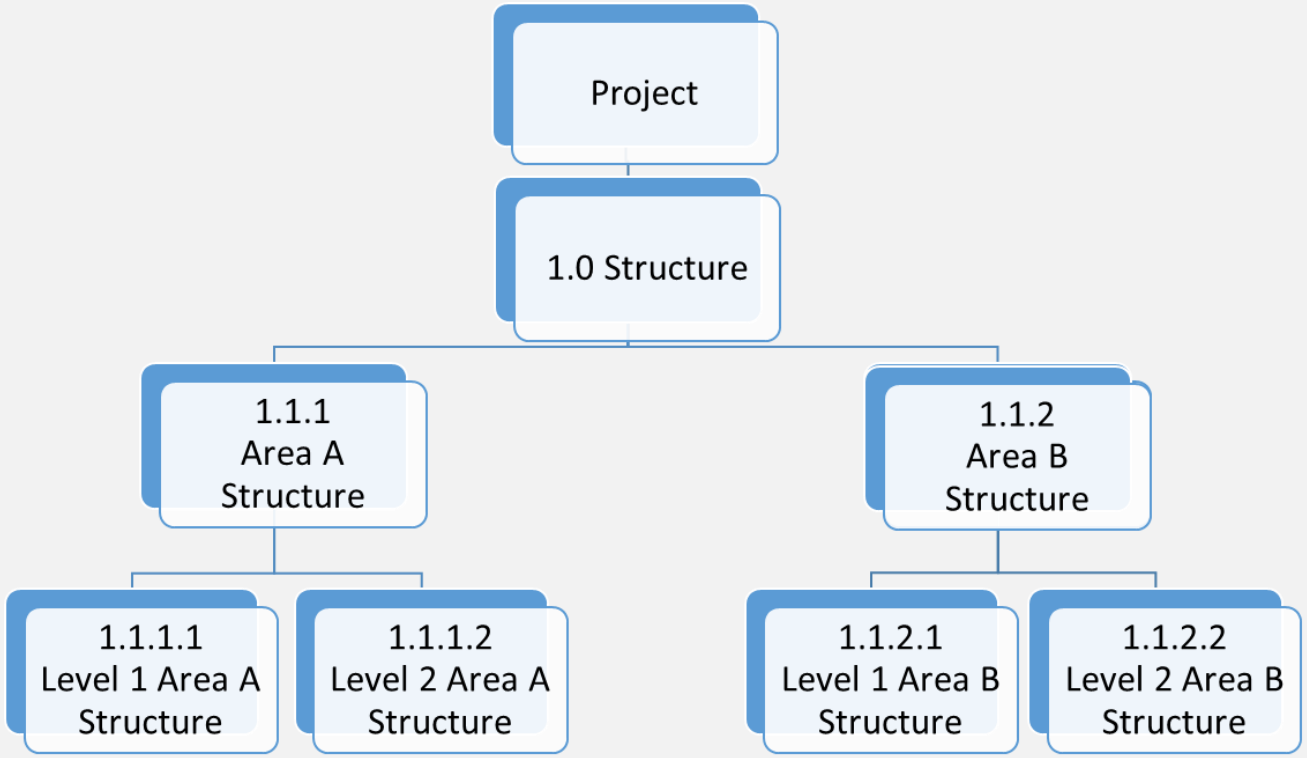
- A Work Breakdown Structure (WBS) is a fundamental project management technique for defining and organizing the total scope of a project, into manageable sections.
- A Work Breakdown Structure (WBS) in project management and systems engineering, is a deliverable-oriented breakdown of a project into smaller components
- In P6 the WBS works as an outline for the schedule

Activity Codes vs. WBS

- Lays out the scope of project work.
  - All project tasks must be accounted for
- Provides the foundation of all project estimates
  - Times, costs, resource requirements, etc.
- Helps with the project's organizational structure
  - How tasks relate to one another, authority structure, etc.

Activity Codes vs. WBS

- Break down the project in outline form
- Categorizes the work into unique work plans such as:
  - Structure
  - Area
  - Level



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Activity Codes vs. WBS

Preconstruction

WBS Code	WBS Name	Total Activities
10	PROJECT BASELINE	3519
10.1	MILESTONES	39
10.1.1	CONTRACT MILESTONES	4
10.1.2	CONSTRUCTION MILESTONES (PLANNED DATES)	29
10.1.3	PERMITS	6
10.2	PRECONSTRUCTION	733
10.2.01	COORDINATION	9
10.2.1	BUYOUT / PROCURMENT / SUBMITTALS / DELIVERIES	606
10.2.1.10	ADMINISTRATIVE / PRE-AWARD	6
10.2.1.01A	BID PACKAGE 01A	0
10.2.1.02A	BID PACKAGE 02A	4
10.2.1.02B	BID PACKAGE 02B	2
10.2.1.03A	BID PACKAGE 03A	21
10.2.1.03B	BID PACKAGE 03B	0
10.2.1.04A	BID PACKAGE 04A	5
10.2.1.04B	BID PACKAGE 04B	8

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Activity Codes vs. WBS

Construction

WBS Code	WBS Name	Total Activities
10.4	CONSTRUCTION	2729
10.4.10	INITIAL SITEWORK, UTILITIES & DEMOLTION	89
10.4.10.1	MOBILIZATION / EROSION & SEDIMENT CONTROL	6
10.4.10.2	PHASE 1 INITIAL SITEWORK & UTILITIES	15
10.4.10.3	PHASE 2 INITIAL SITEWORK & UTILITIES	4
10.4.10.4	PHASE 3 INITIAL SITEWORK & UTILITIES	9
10.4.10.4.1	PHASE 3A INITIAL SITEWORK & UTILITIES	4
10.4.10.4.2	PHASE 3B INITIAL SITEWORK & UTILITIES	5
10.4.10.5	PHASE 4 INITIAL SITEWORK & UTILITIES	6
10.4.10.6	PHASE 5 INITIAL SITEWORK / UTILITIES / DEMOLITION	3
10.4.10.6.1	PHASE 5 INITIAL SITEWORK	3
10.4.10.7	GARAGE DEMOLITION & ALLEYWAY UTILITIES	42
10.4.10.7.8	EXCAVATION / DEMOLITION	26
10.4.10.7.8.1	PILES 1-35	12
10.4.10.7.8.2	PILES 36-70	9
10.4.10.7.8.3	UNDERPINNING	5
10.4.10.8	GEOTHERMAL & CAISSONS	4

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Activity Codes vs. WBS

Activity Codes are values that are assigned to activities that allow you to sort, filter, group, and report on activity information.

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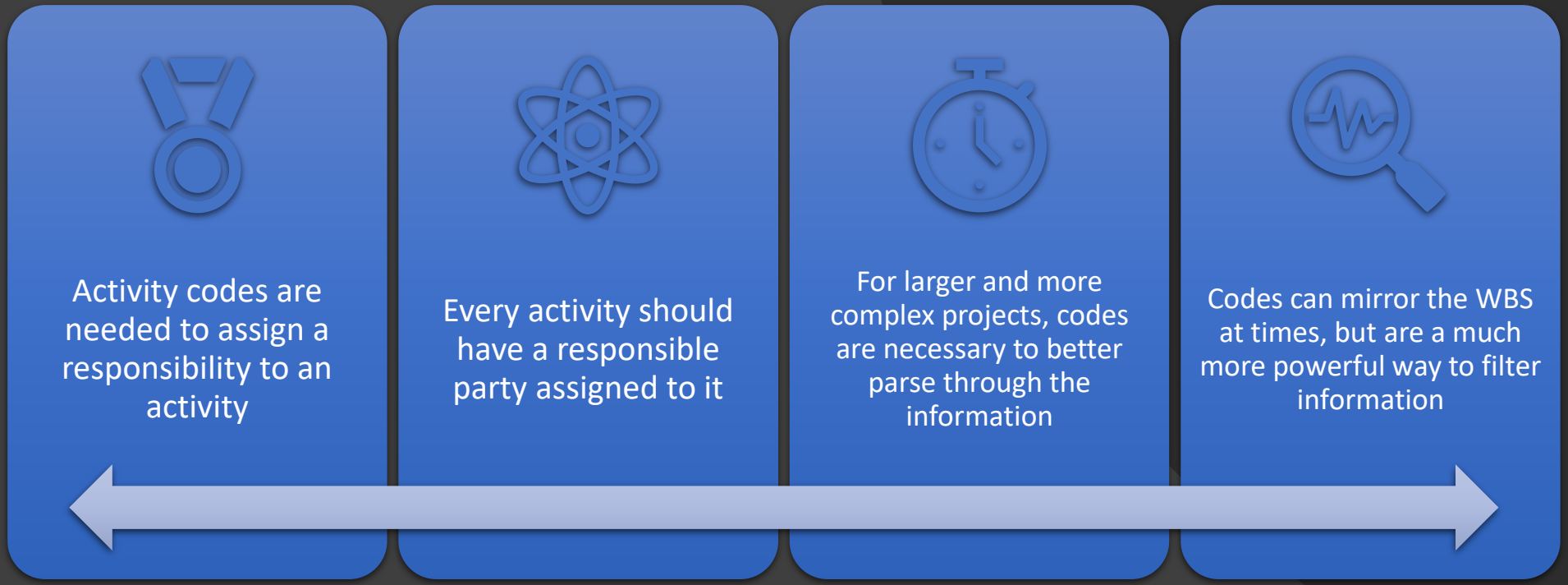
Activity Codes vs. WBS

Why use Activity Codes?



Activity Codes vs. WBS: Activity Codes

Pros

- Group & Sorting Activities into specific categories in the schedule are easier
- Un-limited Flexibility and Coding Ability
- Easier to Filter Activities
- Can be combined with WBS for additional coding

Cons

- Depending on the Activity Code Type (Global, EPS, Project) codes in layouts don’t stay from iteration to iteration.
- Not as easy to imagine the coding structure based on activity codes

PROJECT CONTROLS

Activity Codes vs. WBS

Pros

- Copy and Pasting Groups of activities is easier
- More versatile in tracking cost and time.
- Easier to Visualize your Structure
- Layouts using WBS coding don’t get messed up from iteration to iteration
- Can be combined with Activity Codes for expanded coding

Cons

- Not easy to Filter

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Activity Codes vs. WBS

Should the schedule be organized by WBS, Activity Codes, or both?

For years, the standard grouping of activities was organized by activity codes	Currently, this traditional practice has shifted to WBS organization

Reasons for the recent transition of activity codes to WBS:

WBS provides a static grouping for the Project that always transfers with the schedule file	It is the simplest way to define the areas of a schedule	WBS elements can be copied as templates easily

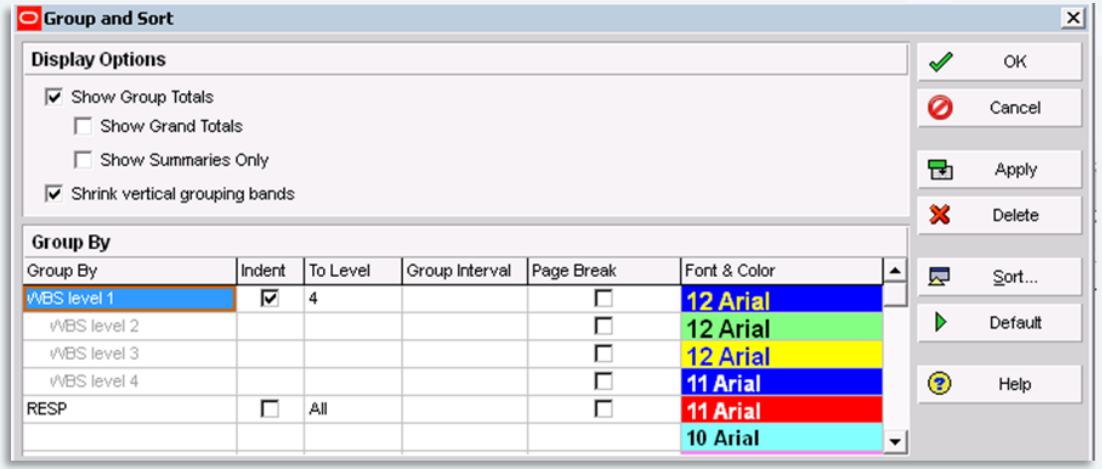
Activity codes vs WBS

Although both organizational schemas are similar there are differences between the two:

WBS Structure	Activity Codes
• Build a sequential structure • Copy/Paste sections • Good tool for organization • Filters and alphanumeric	• flexible, sorting and more filtering • Use of natural language • Consider prior to implementing

Activity codes vs WBS

By incorporating WBS & Activity Codes, you can see that it allows you to analyze a schedule in further detail than just WBS alone



Construction	930	13-Jan-17	09-Sep-20	0
Mobilization, E&S Controls, Fencing, Clear and Grub	82	13-Jan-17	08-May-17	30
Site Utilities	249	27-Feb-17	07-Jun-18	446
Main Building (Area A, B, C)	836	27-Feb-17	10-Jun-20	63
PRIME CONTRACTOR	566	25-May-17	02-Apr-20	85
MECHANICAL	96	06-Oct-17	02-Apr-18	0
EARTHWORK	109	27-Feb-17	18-Sep-17	0

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Elements of a Logical Schedule

Activity ID’s

Activity ID conventions

- Activity ID's and Activity Names should be redundant

POOL	
G.POOL.1140	US POOLS MOBILIZATION - POOL - G
G.POOL.1050	INSTALL POOL FILTER ROOM EQUIPMENT - POOL - G
G.POOL.1150	INSTALL POOL PLUMBING - POOL - G
G.POOL.1060	INSTALL POOL HEATER - POOL - G

How could this activity ID be improved on?

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Elements of a Logical Schedule

Activity Names

Naming conventions

A consistent convention for naming work activities should be established early in a Project and carried through its completion

Names for all activities, including summary, milestone, and detailed activities, should be unique and as descriptive as necessary to facilitate communication between all team members.

Descriptive activity names ensure that decision makers, managers, activity managers, task workers, and stakeholders know what scope of work is required for each activity.

Naming conventions

- Activities are instructions for someone to carry out, activity names should be phrased in the **present tense** with **location-verb-noun or verb-noun-location** combinations
- Milestone descriptive names should be related to an event or a deliverable, such as “Milestone B complete” or “level 4 test results report submitted.”
- Descriptive names should identify their associated task without the need to review high-level summary activity or preceding activity names.
- An activity name will contain:
  - A definable scope of work
  - One primary trade per activity
  - Definable geographical boundary
    - By Floor/Area/Building
    - OR BY Work Type: Design/Permitting

RM ELEC 1ST FL
1ST FL: ELEC RM

L3- INSTALL STEEL & DETAIL 90 & 91
L3- SET METAL DECK SQ 90 & 91
L3- INSTALL STEEL & DETAIL 100 & 101
L3- INSTALL STEEL & DETAIL 110 & 111
L3- SET METAL DECK SQ 100 & 101
L3- SET METAL DECK SQ 110 & 111

AWARD SUBCONTRACT - 60A IRRIGATIONS SYTEM
SUBMIT FOR APPROVAL - 60A IRRIGATIONS SYTEM
OWNER REVIEW - 60A IRRIGATIONS SYTEM
NAVFAC REVIEW - 60A IRRIGATIONS SYTEM
FAB/DELIVER - 60A IRRIGATIONS SYTEM

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Naming conventions

- Repetitive naming of activities makes communication difficult between teams
- Additionally, team members responsible for updating and integrating multiple schedules will have a difficult time knowing which specific activity they are updating

Activity ID	Activity Name
STRC.L1.1000	L1- INSTALL STEEL & DETAIL SQ 10 & 11
STRC.L1.1030	L1- INSTALL STEEL & DETAIL SQ 20, 21 & 22
STRC.L1.1060	L1- INSTALL STEEL & DETAIL SQ 30 & 31
STRC.L1.1090	L1- INSTALL STEEL & DETAIL SQ 40 & 41
STRC.L1.1100	L1- INSTALL STEEL & DETAIL SQ 50 & 51
STRC.L2.1000	L2- INSTALL STEEL & DETAIL SQ 61
STRC.L2.1020	L2- INSTALL STEEL & DETAIL SQ 71 & 79
STRC.L2.1040	L2- INSTALL STEEL & DETAIL SQ 81
STRC.L3.1000	L3- INSTALL STEEL & DETAIL 90 & 91
STRC.L3.1020	L3- INSTALL STEEL & DETAIL 100 & 101
STRC.L3.1040	L3- INSTALL STEEL & DETAIL 110 & 111
STRC.L4.1000	L4- INSTALL STEEL & DETAIL SQ 121
STRC.L4.1030	L4- INSTALL STEEL & DETAIL SQ 131 & 139
STRC.L4.1050	L4- INSTALL STEEL & DETAIL SQ 141
STRC.L5.1000	L5- INSTALL STEEL & DETAIL SQ 150 & 151
STRC.L5.1030	L5- INSTALL STEEL & DETAIL SQ 160 & 161
STRC.R.1000	R- INSTALL STEEL & DETAIL SQ 180 & 181
STRC.L5.1050	L5- INSTALL STEEL & DETAIL SQ 170 & 171
STRC.R.1030	R- INSTALL STEEL & DETAIL SQ 189, 190 & 191

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Naming conventions

- Provide a dictionary or list of common abbreviations found in the schedule to avoid ambiguity.

Electric Cut/Cap/Make Safe
Mech/Plumb Cut/Cap/Make Safe
MEP Demo
Interior Demo
Demo Concrete (All of West)
Form / Pour New Concrete Slab (All of West)
Form / Pour New Curbs (All of West)
Install Masonry Walls (All of West)
Remove Structural Shoring (All of West)
Frame Walls
Mech/Plumb R/I
Elec R/I
Install Unit Heaters
Sprinkler R/I
Pull Fire Alarm Wire
Wall Close-In Inspection
Hang GB Walls

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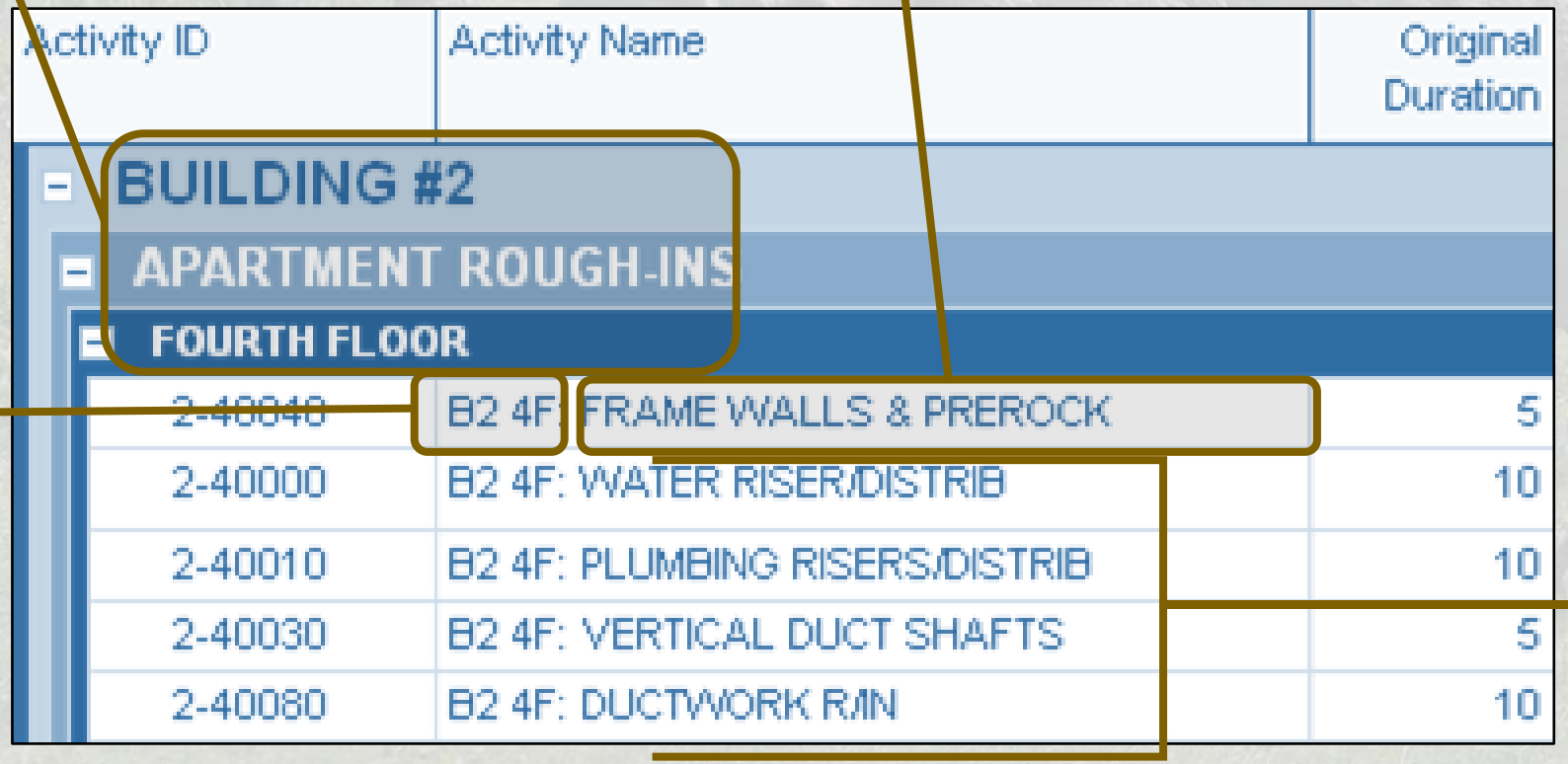
Naming conventions

Definable geographical boundaries or work type

Definable scope of work

One primary trade per activity, e.g. “MEP Rough-In”



Activity ID	Activity Name	Original Duration
BUILDING #2		
APARTMENT ROUGH-INS		
FOURTH FLOOR		
2-40040	B2 4F: FRAME WALLS & PREROCK	5
2-40000	B2 4F: WATER RISER/DISTRIB	10
2-40010	B2 4F: PLUMBING RISERS/DISTRIB	10
2-40030	B2 4F: VERTICAL DUCT SHAFTS	5
2-40080	B2 4F: DUCTWORK R/IN	10

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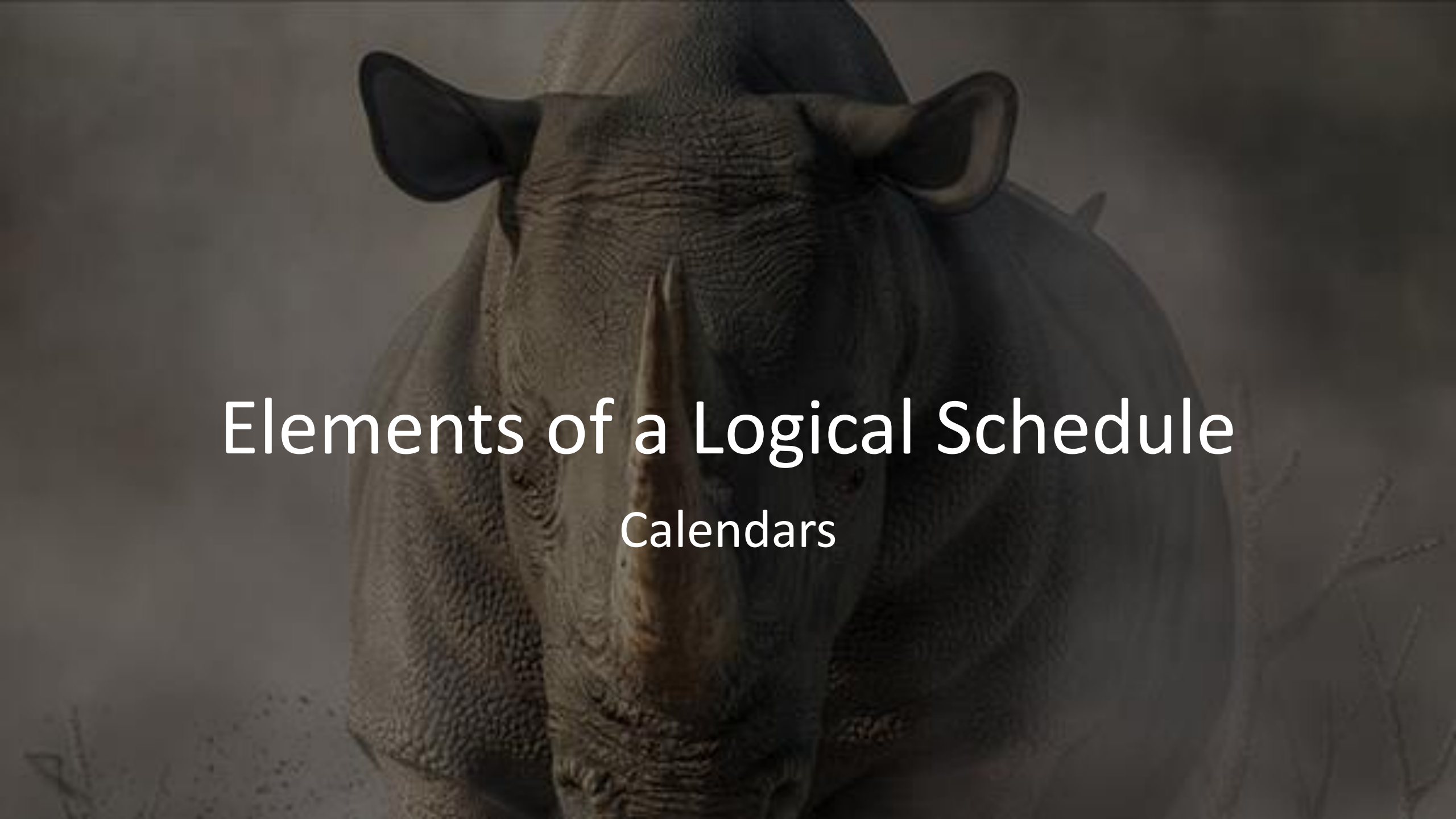

Elements of a Logical Schedule

Calendars

Calendars

- Calendars in schedules specify valid working times for resources and activities.
- Resources can be assigned to calendars to define their availability. The availability of a resource in turn affects the dates and elapsed duration of the activity to which it is assigned.
- Activities should be directly tied to task calendars, which will define the valid times an activity can be worked.
- Calendars are defined by the number of work days per work week as well as the number of hours available each work day.
- Special nonwork days, are defined in resource and activity calendars. Holidays and plant shutdown periods are examples of exceptions at the activity calendar level.

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Calendars

- Another use for a calendar might be to exclude seasonal days from work.
- Outdoor construction probably cannot be conducted when the ground is frozen, or rain is intense. The activity could start before the rain or the freeze but would then have to continue after the end of the exception.
- A calendar that excludes November through February for bad weather could be assigned to all outdoor construction activities. These dates are well known from many years of experience.
- Defining calendars in this way allows for properly scheduling activities automatically according to network logic.
- Automatically updating the schedule gives greater confidence in float calculations and the derived critical paths.

Calendars

- Ensure that calendars are properly defined because schedules can incorrectly represent the forecasted start, finish, and durations of planned work if activities are assigned an incorrect calendar.
- A common mistake allows all activities within a schedule to simply be assigned to the default calendar within the scheduling software.
- A default calendar rarely has national holidays appropriately defined as exceptions and does not define specific blackout periods or related exceptions.
- Similarly, the general project calendar that would have excluded holidays still may not represent the work practices of all resources. For instance, a testing facility may work 24 hours a day while some personnel work 4 10-hour days a week.
- Establishing realistic calendars provides for greater accuracy of dates and may reveal opportunities to advance the work.

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Calendars

- The USACE specification for calendars:

The following schedule of monthly anticipated adverse weather delays is based on National Oceanic and Atmospheric Administration (NOAA) or similar data for the Project Location and will constitute the base line for monthly weather time evaluations. The Contractor's progress schedule must reflect these anticipated adverse weather delays in all-weather dependent activities.

MONTHLY ANTICIPATED ADVERSE WEATHER DELAY WORK DAYS BASED ON (5) DAY WORK WEEK											
JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
5	5	5	3	3	5	8	6	5	3	4	5

What stands out about this specification?

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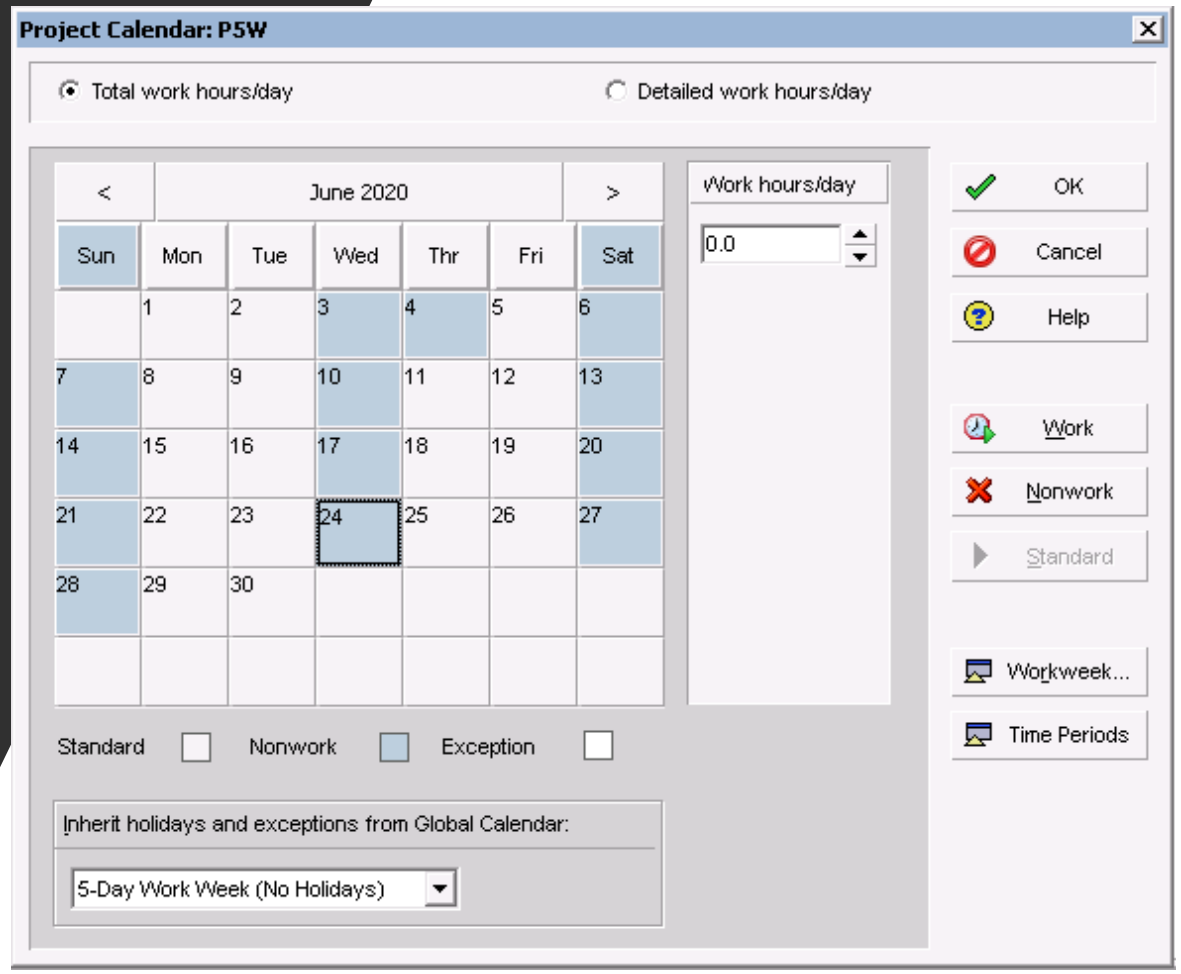
Calendars

- A Weather Calendar randomly blocks out workdays in anticipation of inclement weather
- The number weather days per each month can be specified via:
  - Project specifications
  - Or a review of NOAA weather data
- The Weather Calendar should only be applied to weather sensitive work like:
  - Concrete
  - Sitework
  - Exterior Masonry
  - Exterior Skin
- Tracking
  - Weather form



Elements of a Logical Schedule

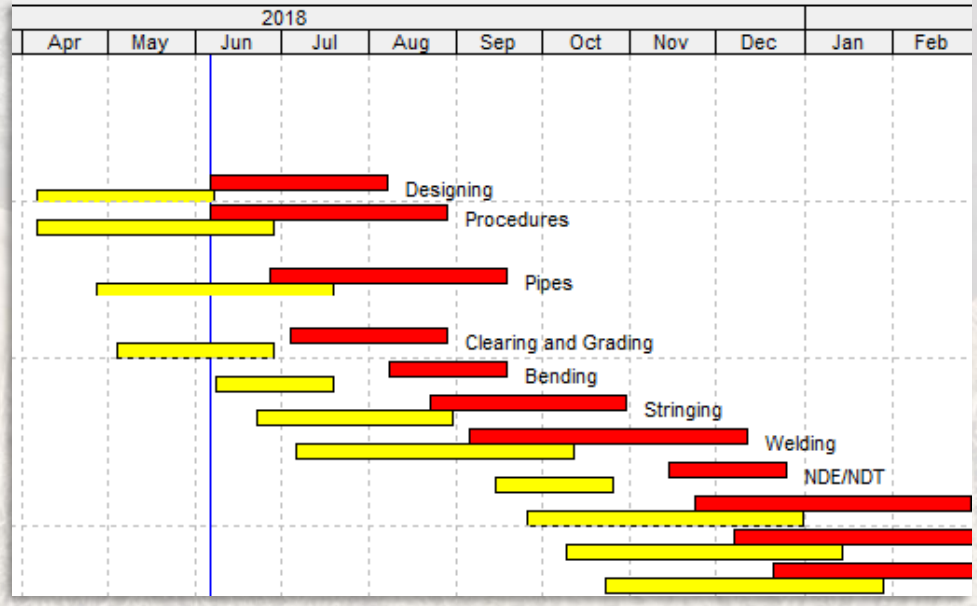
Capturing Logic in the Schedule

Capturing Logic in the Schedule

- The purpose of sequencing activities is to develop a networked schedule that is a predictive model of how the project is to be executed.

- By establishing the network logic, the schedule can predict the effect on the Project's planned finish date, in addition to:

  - misallocated resources
  - delayed activities
  - external events
  - scope changes
  - unrealistic deadlines
  - risk events



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Capturing Logic in the Schedule

Activities that are logically related within a schedule network are referred to as predecessors and successors

A predecessor activity must start or finish before its successor

The purpose of a logical relationship, or dependency, is to depict the sequence in which activities occur

Such relationships state when activities are planned to start and finish in relation to the start and finish of other activities

A logic relationship therefore models the effect of an on-time, delayed, or accelerated activity on subsequent activities

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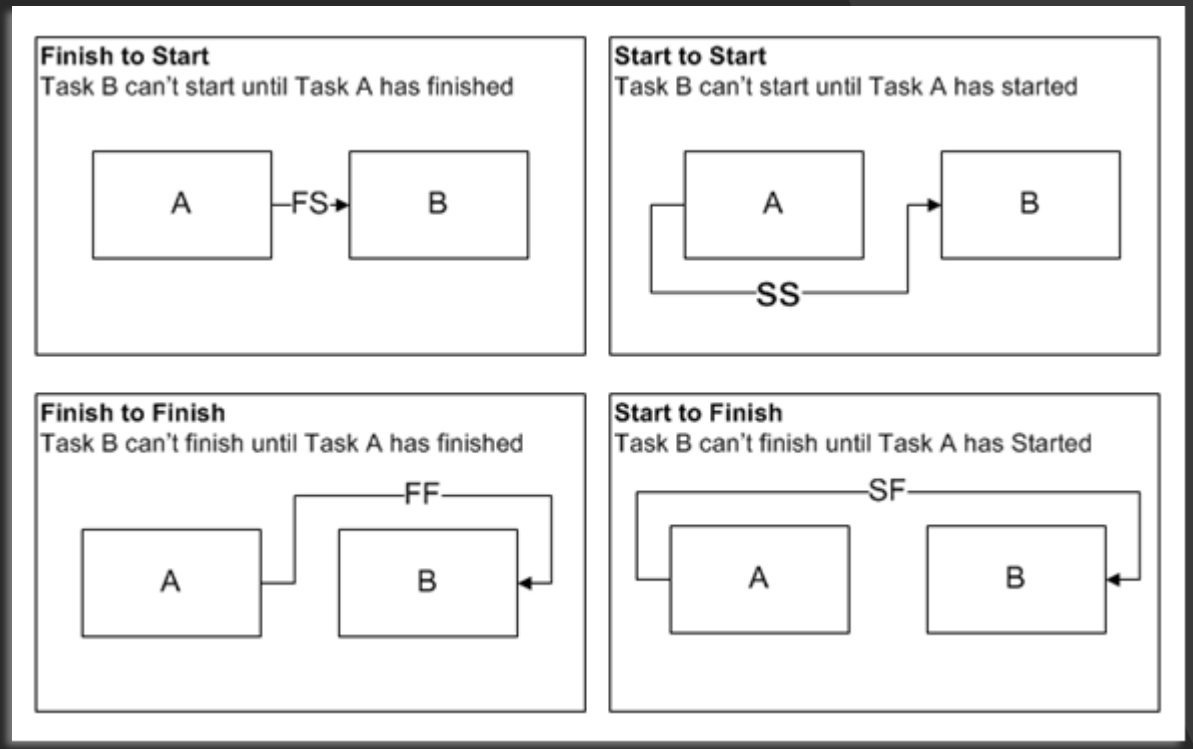
Capturing Logic in the Schedule

- **Finish to Start:** This is the logical link between a predecessor and successor. In it, a successor activity cannot start until the predecessor activity finishes, creating a simple sequence of planned effort. This logical relationship is the default in most scheduling Projects

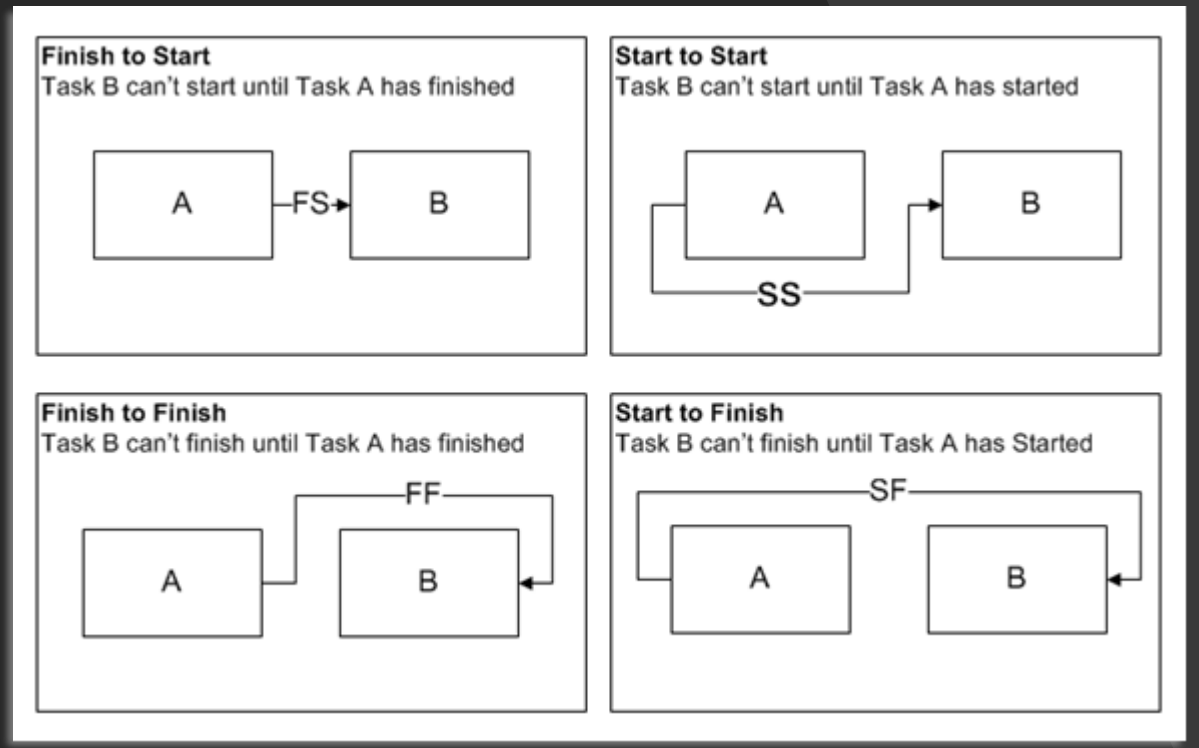
- **Start to Start**: A start-to-start (S–S) relationship dictates that a successor activity cannot start until the predecessor activity starts



Capturing Logic in the Schedule

- **Finish to Finish:** A finish to finish (F–F) relationship dictates that a successor activity cannot finish until the predecessor activity finishes

- **Start to Finish**: The start-to-finish (S–F) link is a theoretical, fourth combination of logical links between predecessor and successor.
  - It has the effect of directing a successor activity not to finish until its predecessor activity starts, in effect reversing the expected flow of sequence logic.
  - Its use is widely discouraged because it is counterintuitive, and it overcomplicates schedule network logic



Capturing Logic in the Schedule

A logic relationship dictates the effect of an on-time, delayed, or accelerated activity on subsequent activities.

Any missing or incorrect logic relationship is potentially damaging to the entire network.

Complete network logic between all activities is essential if the schedule is to correctly forecast the start and end dates of activities within the plan.

Every activity within the schedule should have at least one predecessor and at least one successor.

The two natural exceptions to this rule are the Project start milestone, which has no predecessor, and the Project finish milestone, which has no successor.

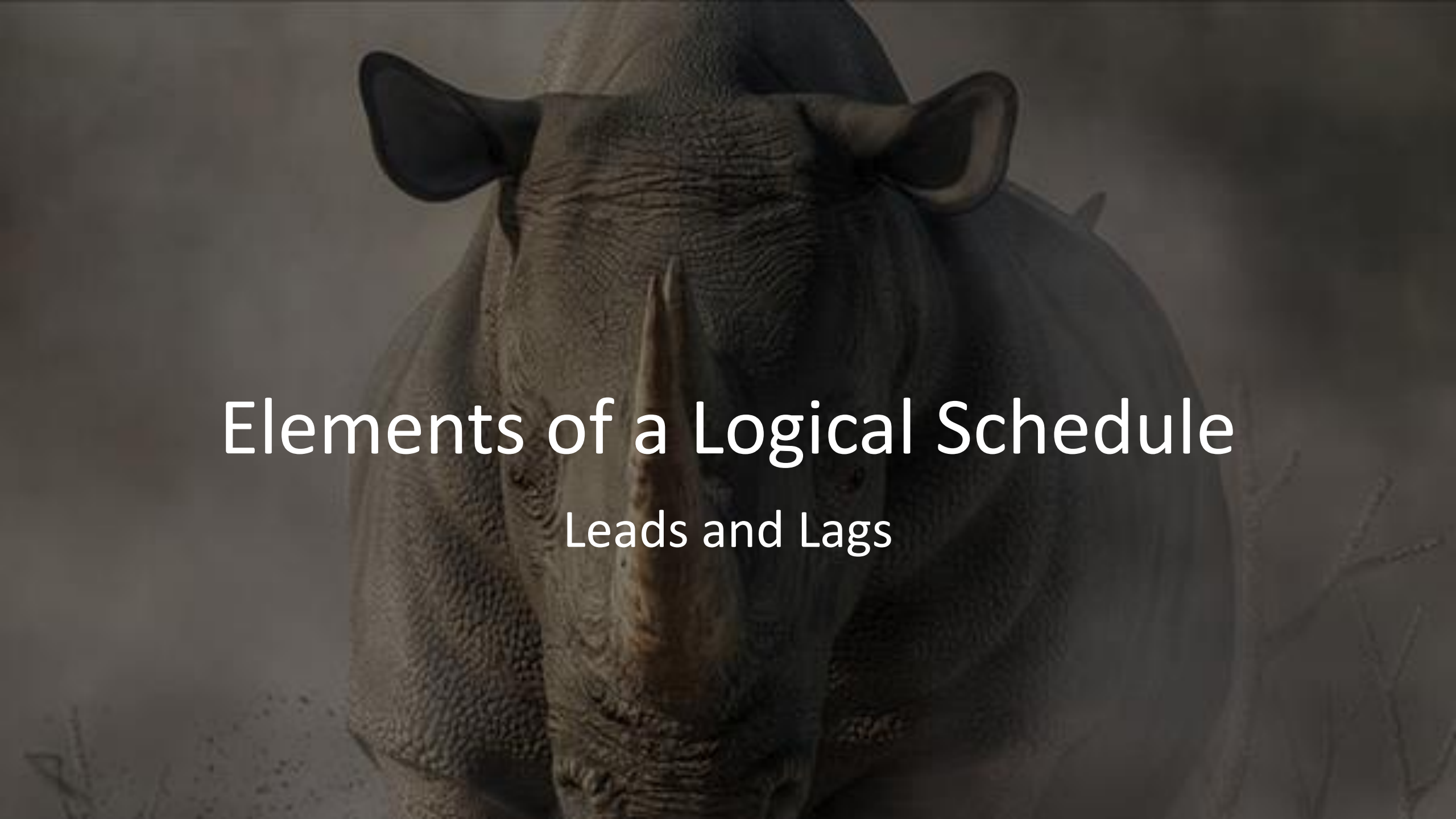
Capturing Logic in the Schedule

Any activity with an F–F predecessor link should also have at least one F–S or S–S predecessor link.

If nothing is driving the start date of the activity, then why not start the activity earlier?

Any activity with an S–S successor link should also have at least one F–S or F–F successor link.

If the finish date of the activity is not driving the start of another activity, then why finish the activity?



Elements of a Logical Schedule

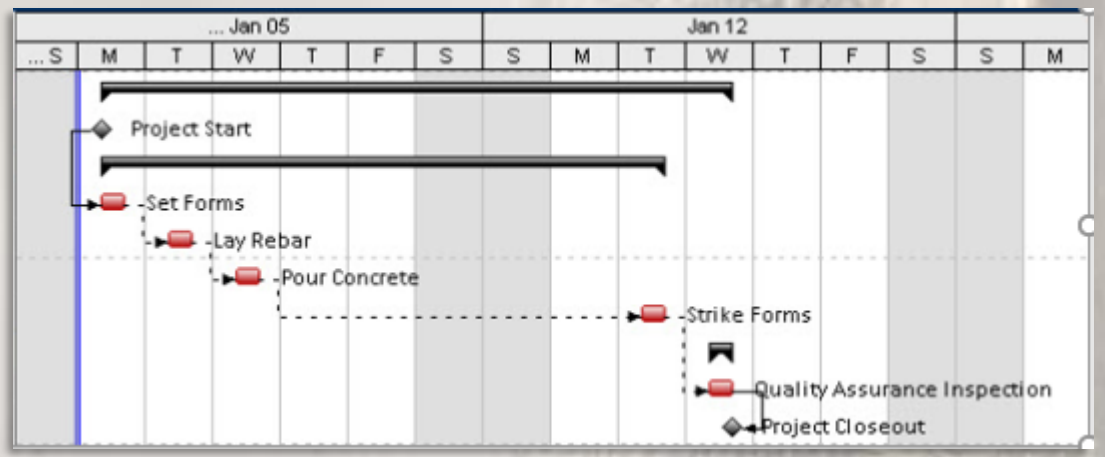
Leads and Lags

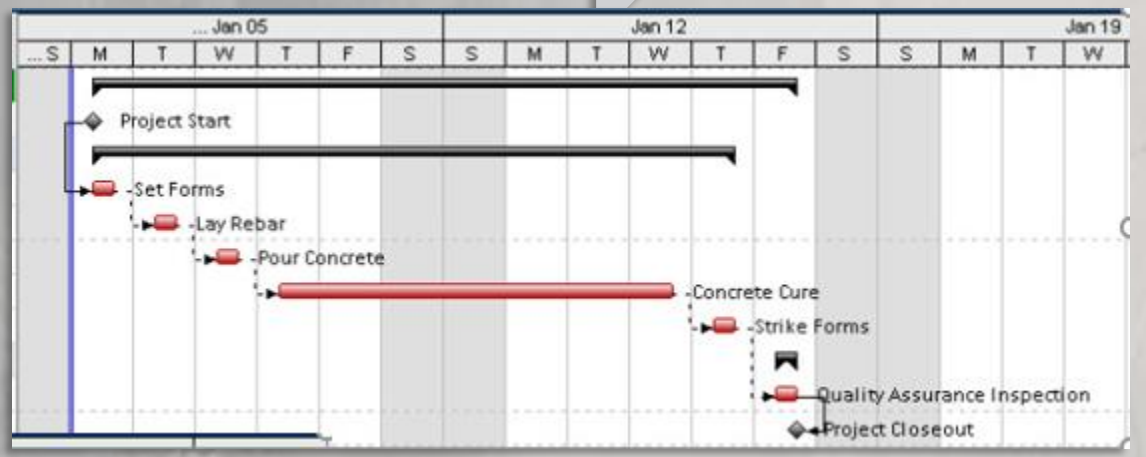
Leads and Lags

A lag in a schedule denotes the passage of time between two activities.

Lags simply delay a successor activity

A common example of the use of a lag is the passage of time to allow concrete to cure.





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Leads and Lags

Note, because lags denote the passage of time, they are often misused to force successor activities to begin on specific dates

A lag is static; that is, the lag will always be the assigned duration unless the scheduler manually changes it

Leads and Lags

Activity	Duration	Start	Finish
Frame first floor floors, install wall sheathing	6 days	10/27	11/3
Install roof trusses	2 days	11/6	11/7

Why is this an Issue?

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Leads and Lags

Lags, like date constraints, must be used prudently. They represent a real need to delay time between two activities.

They must be justified by compelling reasons outside the schedule in the schedule documentation.

F–S relationships with lags are generally not necessary.

In these cases, every effort should be made to break activities into smaller tasks and to identify realistic predecessors and successors so that logic interface points are clearly available for needed dependency assignments.

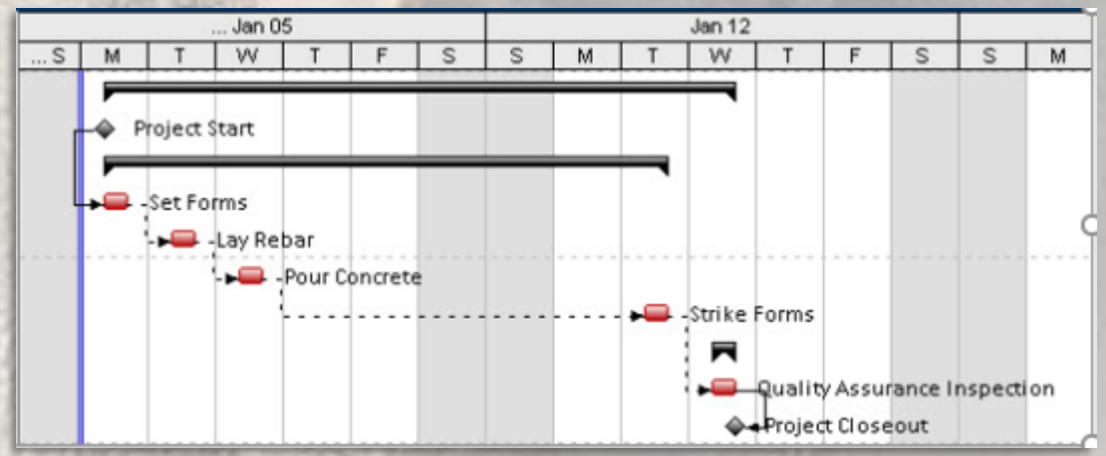
If used improperly, lags can distort float calculations in a schedule and can corrupt the calculation of the critical path.

Lags are useful in summary and intermediate schedules because portions of long-term effort are likely to be unknown, or one may wish to reduce the number of activities displayed in high-level reports.

Lags are usually used in places where detail is not sufficient to identify the needed interface points for making proper relationships, as in early summary-level schedules.

Leads and Lags

A negative lag, known as a lead, is used to accelerate a successor activity.



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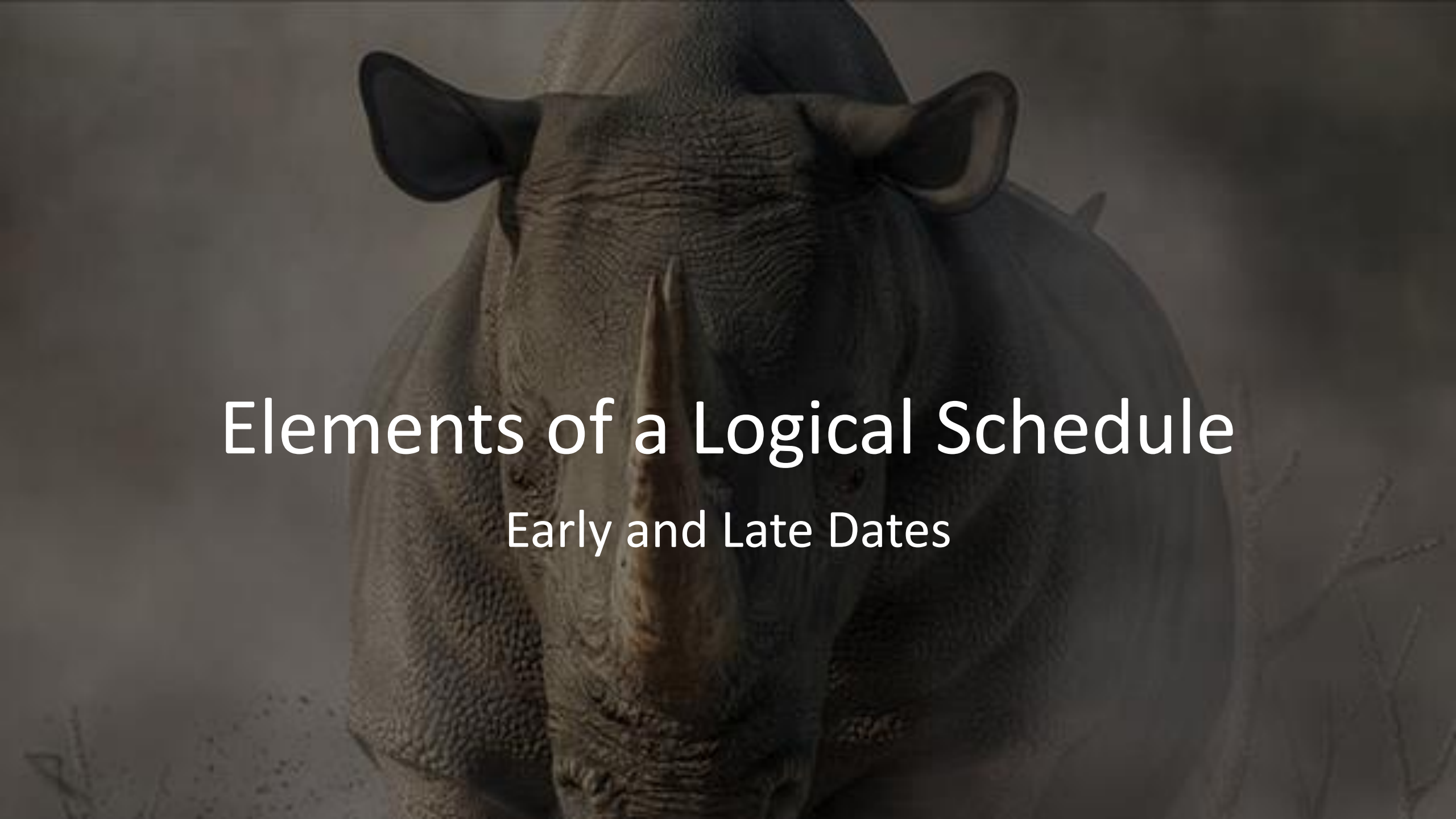
Leads and Lags

Leads, are often unnecessary. As negative lags, leads imply the unusual measurement of negative time and exact foresight about future events.

In effect, a lead indicates that a future event will dictate the timing of an event in the past, which is neither logical nor possible



Elements of a Logical Schedule

Early and Late Dates

Early and Late Dates

Once the logic that creates a network has been established, the scheduling software can calculate a set of start and finish times for each activity, given the relationship logic and the estimated duration of each activity.

Ideally, only one date should be entered into the scheduling software; the project start date. All other dates are calculated by the network logic.

Network logic calculates activity dates that define both when an activity may start and finish and when an activity must start and finish to meet a specified Project completion date.

These are known as early and late dates, respectively.

Early and Late Dates

Early Start	Early start defines the earliest time when an activity may start.
Early Finish	Early finish defines the earliest time when an activity may finish.
Late Start	Late start defines the latest time when an activity must start in order for the Project to be completed on time.
Late Finish	Late finish defines the latest time when an activity must finish in order for the Project to be completed on time.

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Early and Late Dates

- The difference between an activity's early and late dates is known as total float or slack.
- Total float is an essential output of critical path method scheduling, and its proper management is the foundation

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Elements of a Logical Schedule

Schedule Updates

Schedule Updates

Progress updates and logic provide a realistic forecast of start and completion dates for activities.

Maintaining the integrity of the schedule logic is necessary to reflect the true status of the Project.

To ensure that the schedule is properly updated, people responsible for the updating should be trained in critical path method scheduling.

Schedule Updates

- “Updating” is the process of updating a plan with actual dates, logic, and progress and adjusting forecasts of the remaining effort.
- Updating the schedule is fundamental to efficient resource management and requires an established process to provide continual and realistic updates to the schedule.
- Updates should be regular and fully supported by team members and management. The benefits of updating the schedule on a regular basis include:
  - Knowledge of whether activities are complete, in progress, or late and the effect of variances on remaining effort
  - Continually refined duration estimates for remaining activities using actual progress, duration, and resource use
  - Current status of total float and critical path activities
  - Creation of trend reports and analyses to highlight actual and potential problems.

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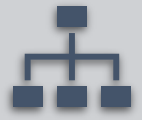
Schedule Updates

The schedule should reflect actual progress as well as other information such as actual start and finish dates, forecasted dates, and logic changes.

The Project Team provides the data to the scheduler. To ensure that the schedule is properly updated, responsibility for changing or statusing the schedule should be assigned to someone who has the proper training and experience in CPM scheduling.



Once an update has been made, the team should assess its accuracy to verify that all finished work is in the past and all unfinished work is scheduled for the future.

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Schedule Updates

- Statusing progress generally takes the form of updating to either durations or work and includes updating the status of remaining work and network logic.
- The data date denotes the date of the latest update to the schedule and defines the distinction between actual work performed and remaining work.
  - All work before and through the data date represents completed effort
  - All work beyond it represents remaining effort.
- Simply put, all dates before the data date are in the past and all dates beyond and equal to the data date project the future.
  - Dates in the past should not be estimated
  - Dates in the future are planned projected dates.

Schedule Updates

Once the schedule has been progressed, the team should review the inputs to verify the updates and assess the effect on the plan. The schedule should be reviewed to ensure the following:

- All activities completed before the data date represent finished work and should have actual start and finish dates.
- In-progress activities should have an actual start date and all work scheduled before the data date is expressed as actual duration or actual effort.
- All remaining work should be scheduled beyond the data date.
- Activities beyond the data date represent future activities and therefore should not have actual start or actual finish dates.
- Date constraints are revisited and removed if possible. In particular, soft constraints should be removed if they can no longer affect an activity's start or finish date.

Elements of a Logical Schedule

Understanding the Critical Path

Understanding the Critical Path

- The critical path is generally defined as the longest continuous sequence of activities in a schedule. It defines the Project's earliest completion date or minimum duration.
- Activities on this path are termed "critical path activities." The sequence of activities with the longest total duration is also the path through the network with the lowest total float.
- When the network is free of date constraints, critical activities have zero float, and therefore any delay in the critical activity causes the same day-for-day delay in the Project forecast finish date.
- The critical path is useful as a tool to help determine which activities deserve focus and, help.
- The critical path assists the project in prioritizing resources to have the most positive effect on Project performance

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Understanding the Critical Path

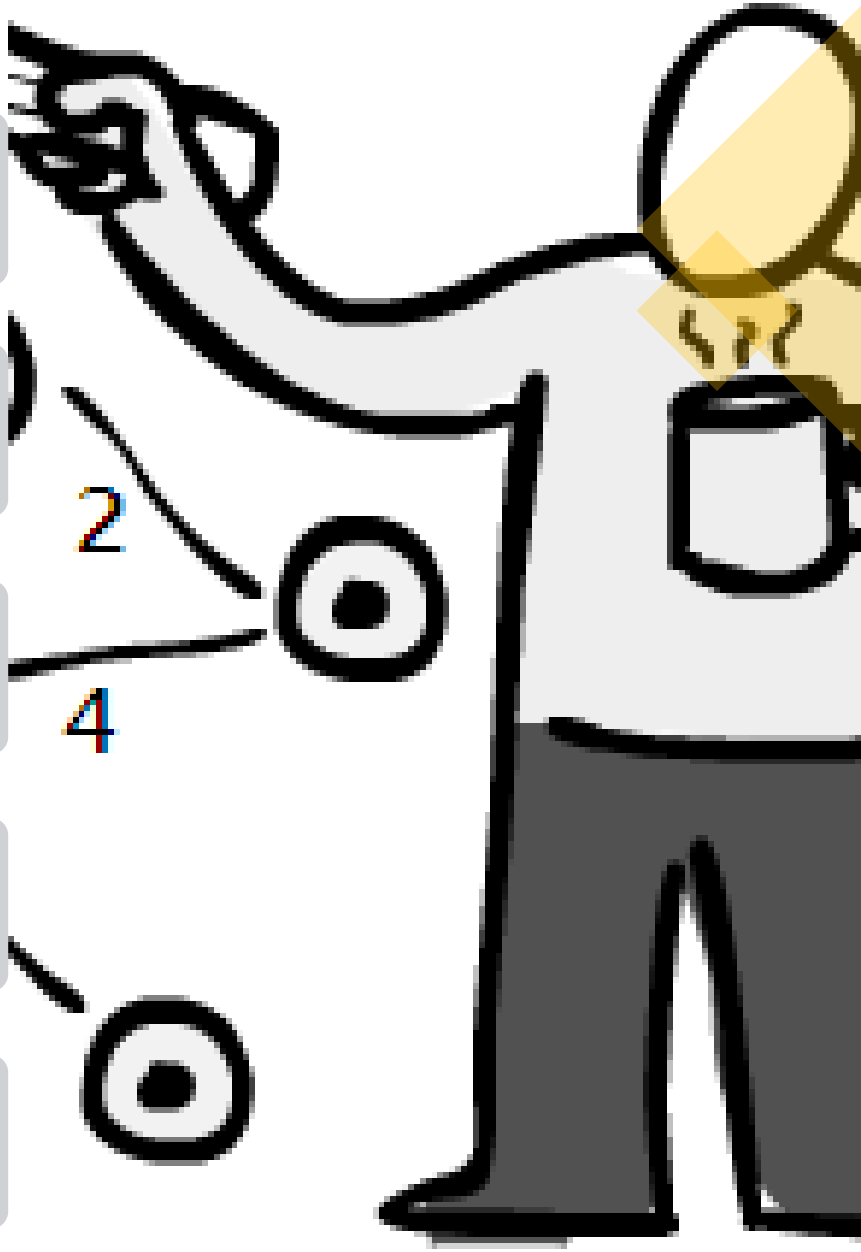
Activities with total float within a narrow range of the critical path total float are “near-critical” because they can quickly become critical if their float is used up in a delay

Near-critical paths need only a small extension of time to become critical.

The team must monitor critical and near-critical activities through sound schedule management because any delay in them will delay the entire Project.

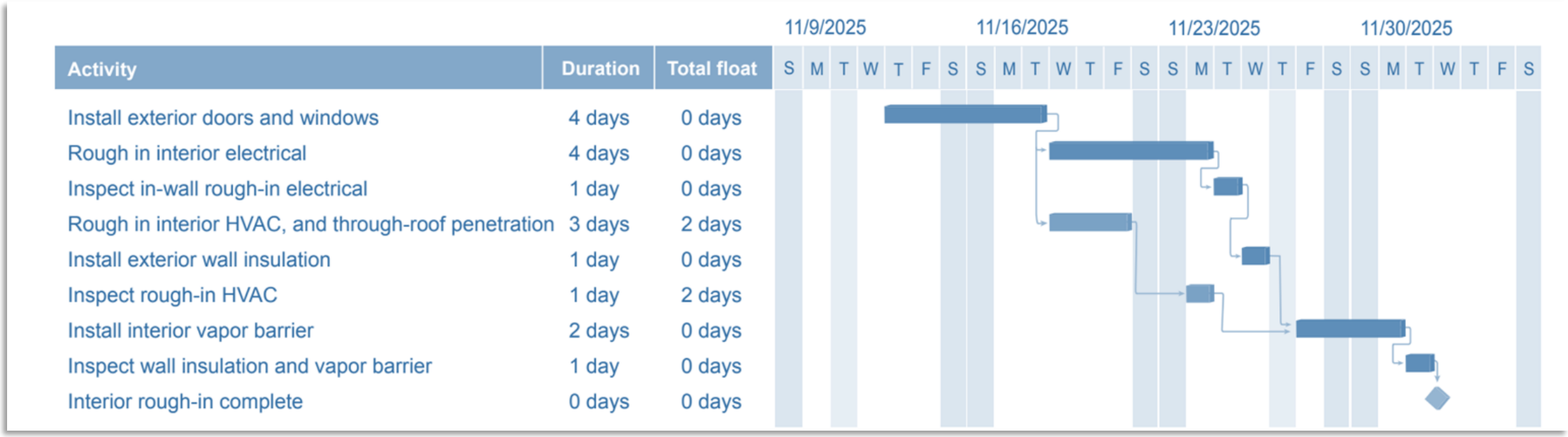
The critical path is not constant. The sequence of activities that make up the critical path changes as activities are delayed, finished early, occur out of planned sequence, and so on.

Activities that were previously critical may become noncritical, and activities that were not critical may become critical.



Understanding the Critical Path

Review and analyze near-critical paths because these activities are likely to overtake the existing critical path and drive the schedule



Activity	Duration	Total float
Install exterior doors and windows	4 days	0 days
Rough in interior electrical	4 days	0 days
Inspect in-wall rough-in electrical	1 day	0 days
Rough in interior HVAC, and through-roof penetration	3 days	2 days
Install exterior wall insulation	1 day	0 days
Inspect rough-in HVAC	1 day	2 days
Install interior vapor barrier	2 days	0 days
Inspect wall insulation and vapor barrier	1 day	0 days
Interior rough-in complete	0 days	0 days

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Resource Management
and
Cost loading for proper cash flow

Resource Management

A resource is anything required to perform work.

- Because resource requirements directly relate to an activity's duration, assigning resources to activities ensures that the duration of activities using them will be realistic and rational.
- Because labor, material, equipment, burdened rates, and funding requirements are examined to determine the feasibility of the schedule, resources provide a benchmark of the Project's total and reporting-period costs.

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Resource Management

The process of assigning labor, materials, equipment, and other resources to specific activities within the schedule is known as loading resources.

A resource-loaded schedule therefore implies that all required labor and significant materials, equipment, and other costs are assigned to appropriate activities.

The schedule should realistically reflect the resources that are needed to do the work and when compared to total available resources

This should determine whether all required resources will be available when they are needed.

Resource Management

The amount of work, in person-days, required to complete an activity is equal to the duration of the activity multiplied by the number of labor resource units assigned.

The duration of an activity is directly related to how much work is necessary to complete the activity divided by the number of people available to perform the work.

This does not mean that doubling available resources will halve the activity's duration.

If the amount of work is known, along with an estimate of the number of people available to perform that work, then its duration can be estimated, along with efficiency levels, risk, and other external factors.

When the amount of work is fixed, the number of labor resources directly affects its duration.

Productivity factors can be applied to resources to account for standard output rates, personal experience, or historical productivity.

Productivity varies by the type of work

Workflow also affects productivity: a steady flow of work tends to increase efficiency, whereas a discontinuous flow can introduce inefficiencies

Complex activities may require additional duration as more people are assigned to account for greater communication and coordination requirements.

The duration of other types of activities known as fixed-duration activities is not affected by the number of people assigned to perform the work.

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Resource Management

Including resources in a schedule helps management compute total labor and equipment hours, calculate total project and per-period cost, resolve resource conflicts, and establish the plan.

A schedule ***without*** resources implies an unlimited number and availability of resources

Resource information can be stored within the schedule files or it can be stored externally in separate software

Fully loading the schedule with resources, including materials, equipment, direct labor, travel, facilities, equipment, and level-of-effort activities, can be used to monitor the project.

Best practice is to store resources in the schedule itself

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Resource Management

Activity owners responsible for managing the day-to-day effort and the most experienced team members who will be performing the work are the best source of resource estimates.

Activity owners must be able to explain the logic behind their resource estimates; if there is no justification for allocating and assigning resources, the schedule will convey a false accuracy.

Estimated resources within the schedule should also reconcile with the cost estimate.

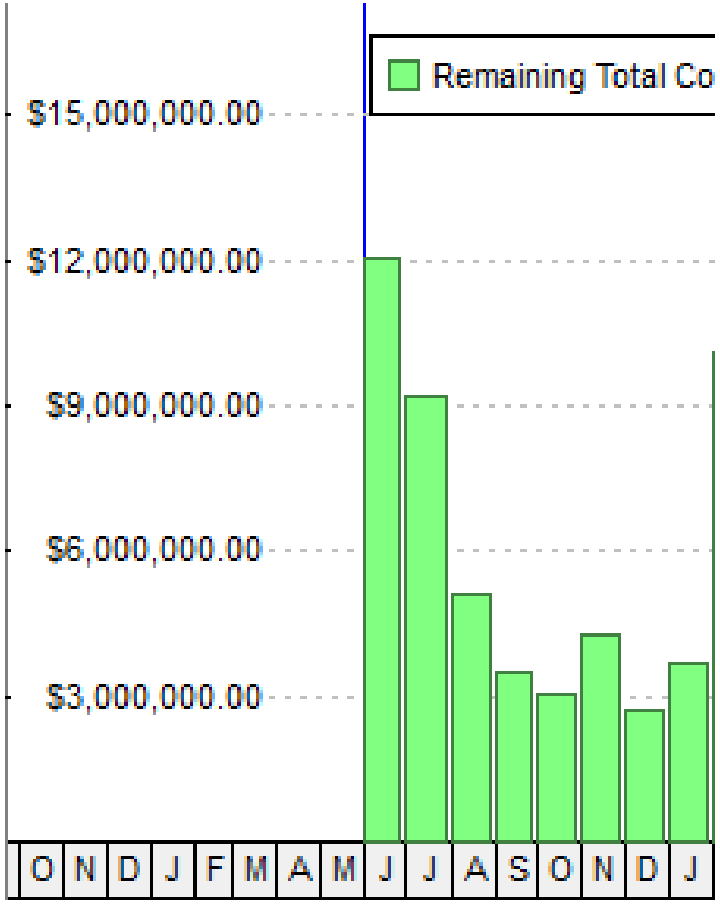
The assumptions for resources and related activity cost should be the same as those that are used in estimating activity duration.

The basis of estimate (BOE) is the connection between cost and time and should be kept up to date as assumptions change.

If durations, resources, or productivity rates change, the cost is also likely to change, and they need to be coordinated.

Both the schedule and the cost estimate should be thoroughly documented to include underlying resource assumptions for the entire estimated scope of work

Resource Management



Review the early curve for spikes and the possibility of stacking on the data date

Typically monthly updates will begin to stack work within the next period and the cost curve will show this graphically

The scheduler should attempt to push out work that is not planned to start within this next period in order to correct this spike at the data date

Similarly for manpower the projection might reveal a need for more men for a trade than currently available. Either the schedule should be adjusted to smooth this peak or the trade should be notified of the need to increase manpower

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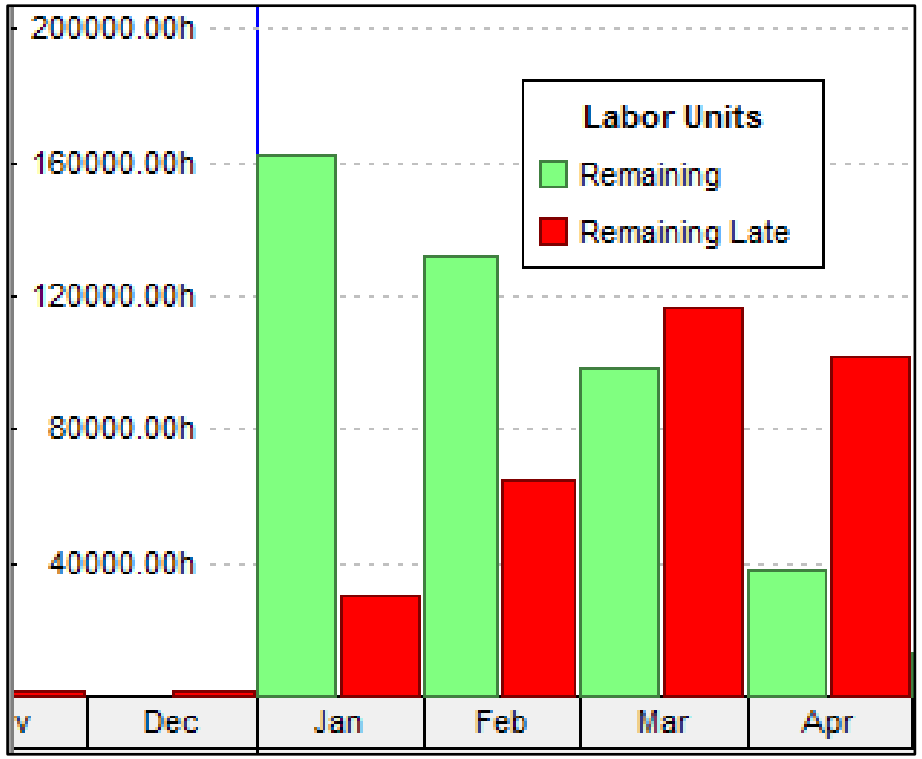
Resource Management



Review the late curve for peaks that exceed the early curve

- The late curve peak should not be exceedingly higher than the early curve peak
- A high late curve peak is an indication that additional logic should be added to the schedule

Review the late curve for large variations from the early projection

- This is an indication that a lot of non-critical work is planned within a period
- The activities should be reviewed and logic could be added to either move the activities or to better constrain the activities by removing their float

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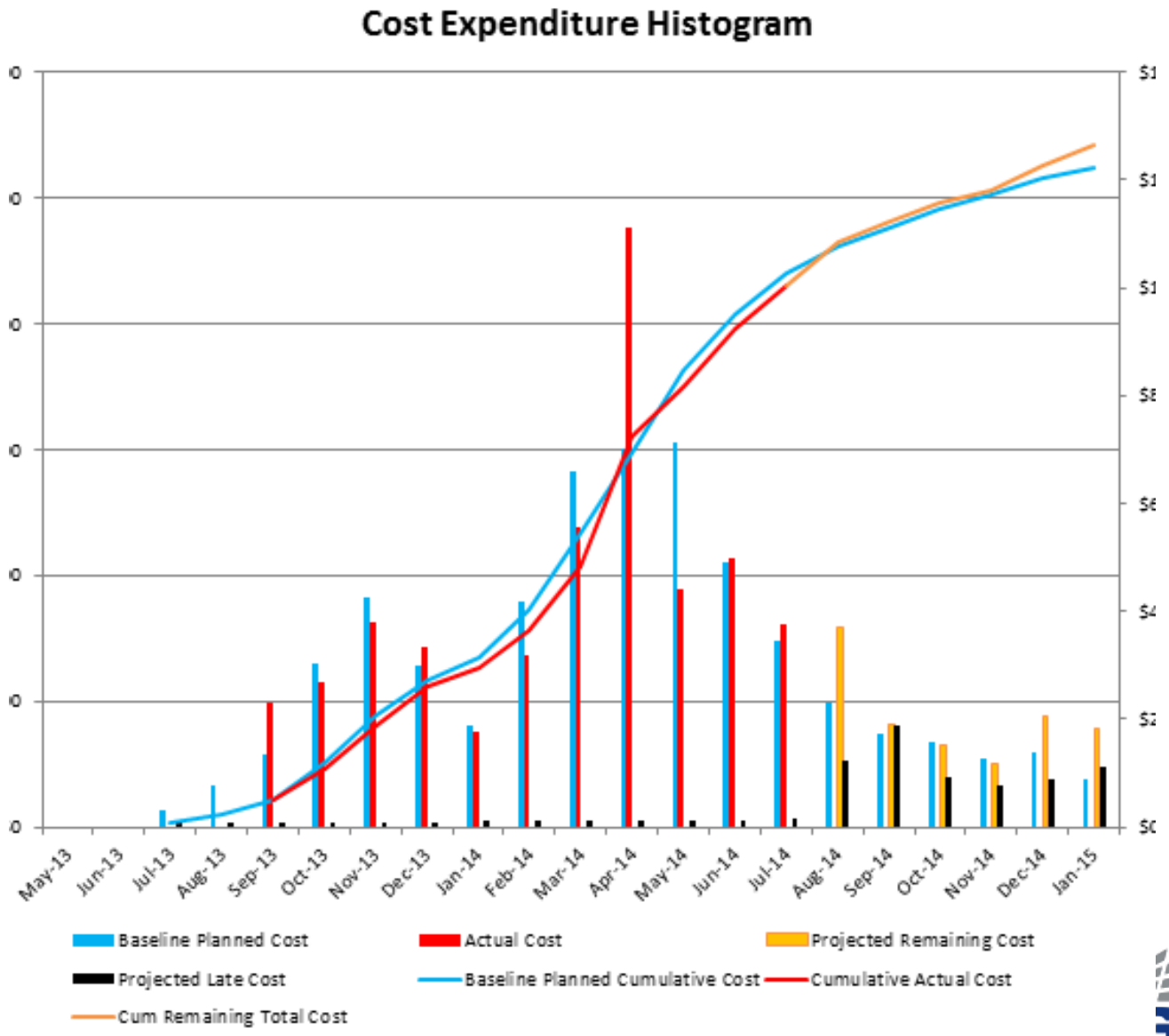
Resource Management



PROJECT CONTROLS

Resource Management

Resource leveling adjusts the scheduled start of activities or the work assignments of resources to account for their availability

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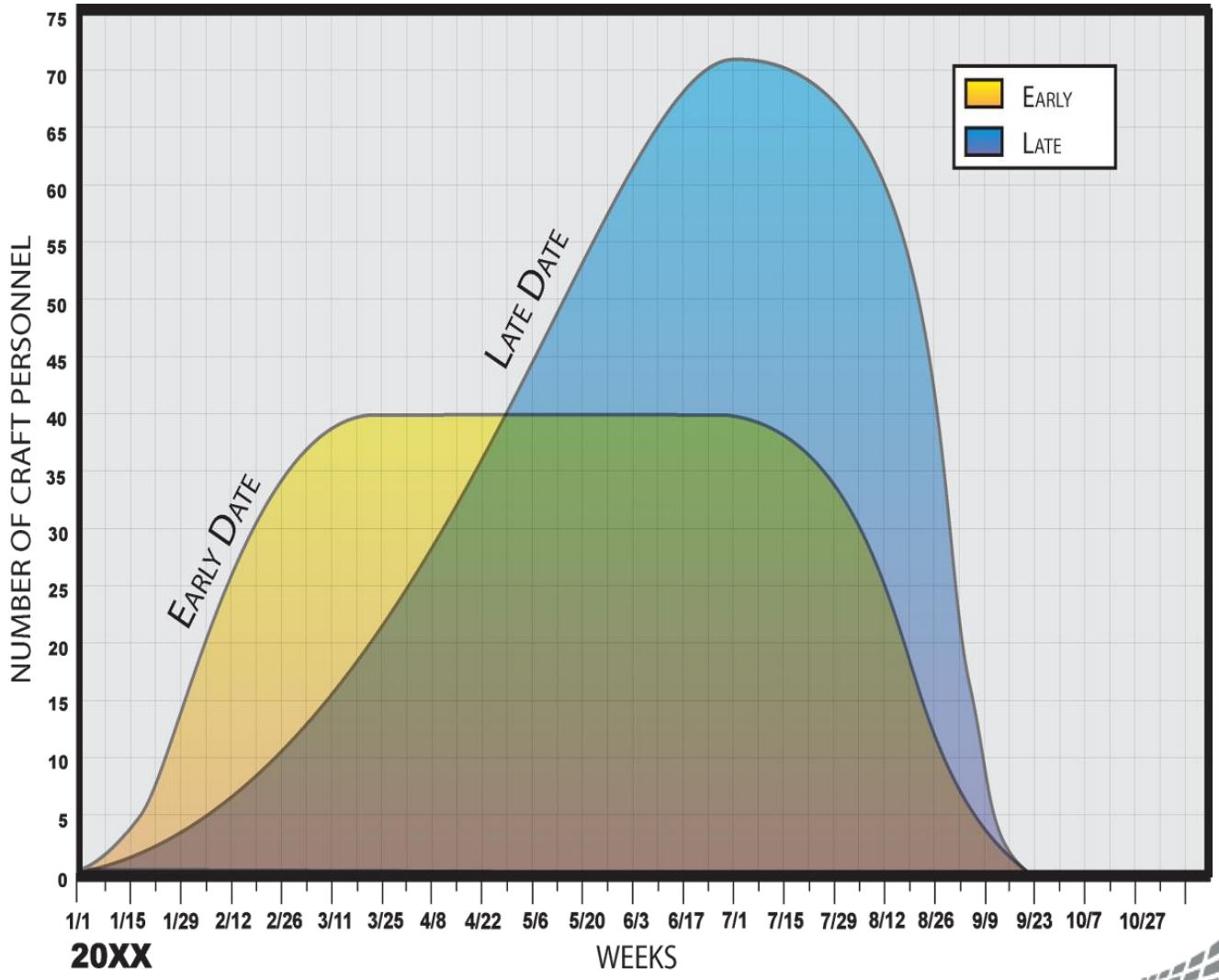
Resource Management

- The graph shown is an example of a Resource Curve in a schedule that is missing Crew Restraints
- Observations:
  - The Early Manpower Peak is 40 workers
  - The Late Manpower Peak is approx 70 workers
  - Therefore, this schedule is indicating that if there are delays on the project, the contractor can increase his crew size by 75% without an issue
  - Note that the Early Curve crosses the Late Curve at approximately May

What can we conclude from this observation?



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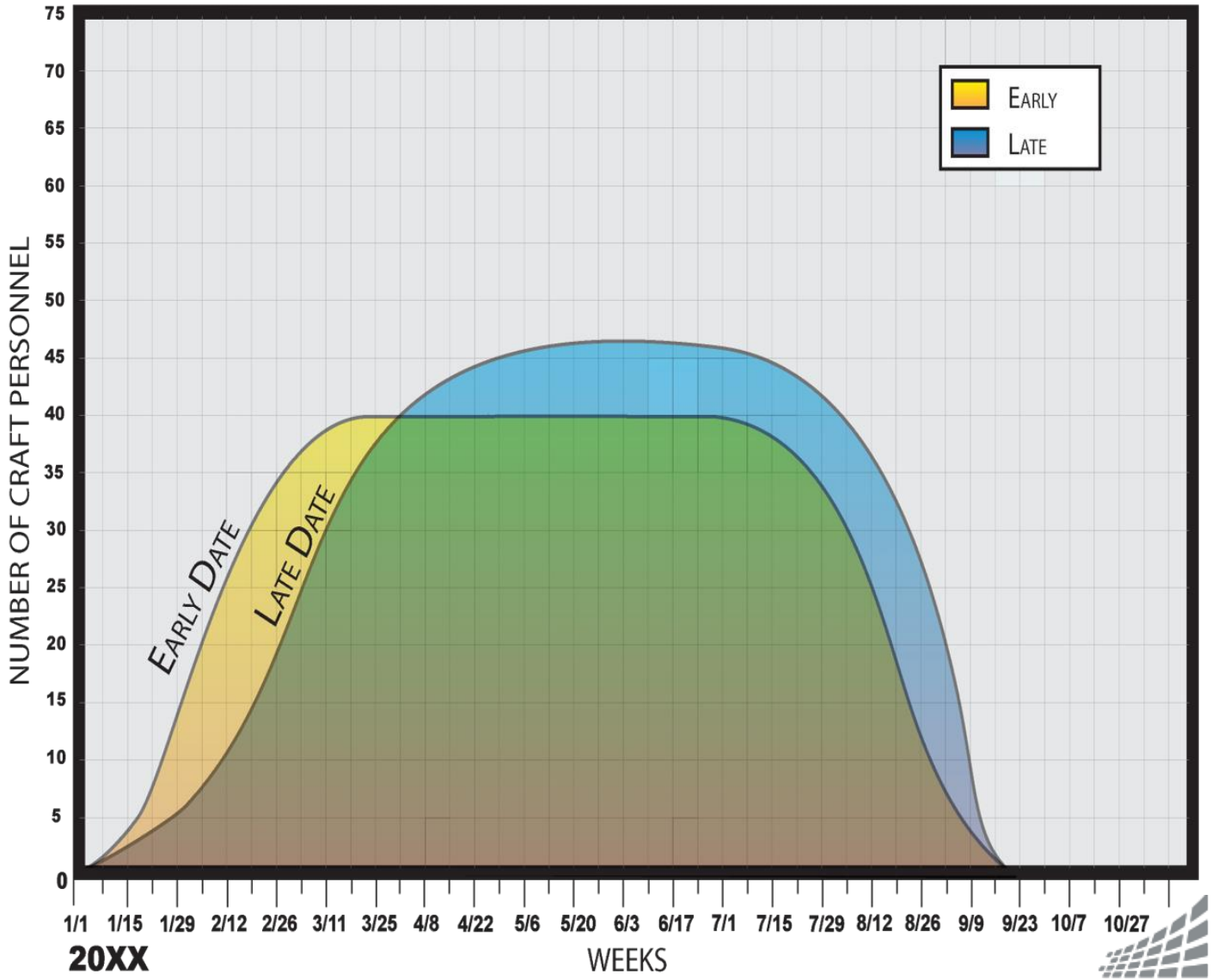
Resource Management

- The graph shown is an example of the same schedule's Resource Curve, but it contains additional Crew Restraints
- Observations:
  - The Early Manpower Peak is still 40 workers
  - The Late Manpower Peak is now only 47 workers
  - Therefore, this schedule is indicating that if there are delays on the project, the contractor can increase his crew size by only 18% without an issue
  - Note that the Early Curve crosses the Late Curve at approximately April 1 (1 month earlier than when crew restraints were missing

What can we conclude from this observation?



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Resource Management

Leveling can be as simple as reassigning work from overallocated resources to under allocated resources or delaying the start date of activities until the required resources are available

Leveling may also develop into a complex trade-off between the required duration of the plan and the availability of resources

The goal of resource leveling is to finish the project on time or early, if possible, with the resources realistically expected to be available throughout the entire plan.

Leveling resources allows management to identify critical resources

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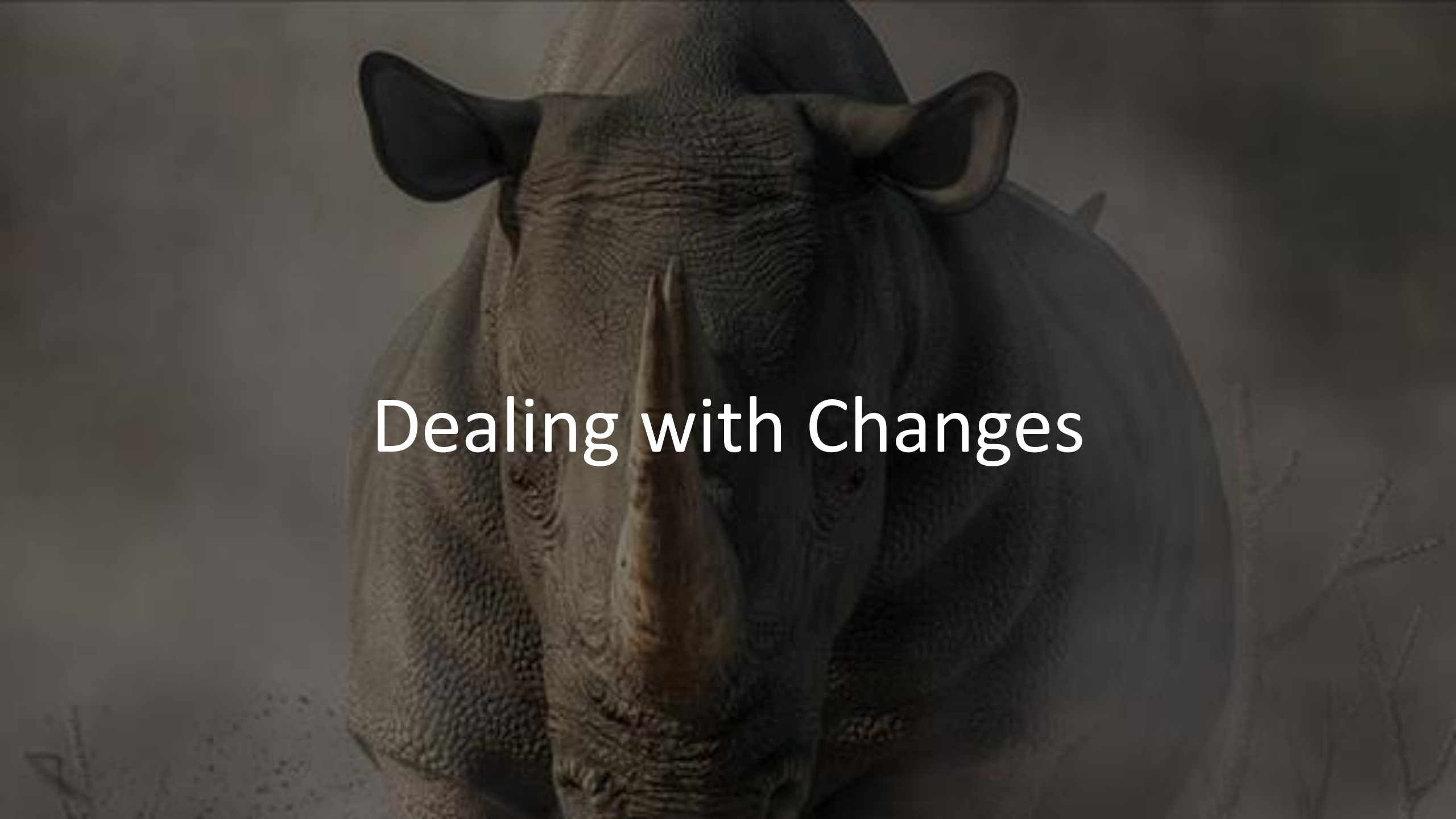

Dealing with Changes

Dealing with Changes

Different type of work from that contained in the contract.
Different quantity of work from that contained in the contract.
Working in different conditions than could reasonably be inferred in the contract.
Request for proposal.
RFI response.
Bulletins, ASI, Field Orders.
Differing site condition.
Submittal review comments.
MEP coordination/conflicts.
Design change.
Specification change.

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Dealing with Changes

Baseline Schedule

- The baseline schedule is not the same as the current schedule.
- The baseline schedule represents the Project's commitments to all stakeholders.
- Deviations from the baseline inform management that the current plan is not following the original plan all stakeholders have agreed to.
- Deviations imply that the current approach to executing the Project needs to be altered to align the Project to the original plan or that the plan from this point forward should be altered
- Without a formally established baseline schedule to measure performance against, the project lacks the ability to identify and mitigate the effects of unfavorable performance.

Current Schedule

- The current schedule is updated from actual performance data.
- The current schedule it the latest depiction of performance and accomplishments, along with the latest forecast of remaining dates and logic.
- The current schedule represents the actual plan to date
- The current schedule is compared to the baseline schedule to track variances from the plan.
- Comparing the current status of the schedule to the baseline schedule can help managers identify the cause of the deviation.

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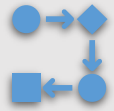
Dealing with Changes

Schedules deviate from the baseline as a Project is executed.

Changes in resource availability, late or early key deliveries, unexpected additional work activities, and risks can contribute to deviation.

Variances provide valuable insight into Project risk and its causes.



Understanding the types of activities that have started earlier or later than planned is vital as well.

Variances allow the project to decide how best to handle risks.

Schedule deviations from the baseline plan give the project information about whether corrections will bring the Project back on track or completion dates need updating.

A schedule variance does not necessarily mean Project delay; it means that work was not completed as planned.

Negative schedule variances should be investigated to see if it is on the critical path.

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Dealing with Changes

- A latent defect is hidden or concealed defect, which would not have been discovered through a reasonable inspection, and one where the Owner has no knowledge of the issued
- A patent defect is something that detectable with a reasonable inspection
- Its important to prepare against a potential claim by knowing when the latent defect manifested itself to the Owner and the contractor
- Its important to make sure a latent defect does not turn into a patent defect due to inaction.

Dealing with Changes

Notice refers to the responsibility of the Contractor to inform the Owner, construction manager, architect or Owner's representative of a possible additional entitlement of time and or monies due to a claim or change event.

Notice allows the Owner to review and investigate the claim for entitlement before the work is performed and monies are spent addressing the issue.

The contract or the specifications will dictate the means the time frame and the manner in which notice is to be given.

Many contracts are written if proper notice is not given within a certain time period, often 7-14 calendar days, then the contractor has forfeited rights to additional time and or monies.

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Dealing with Changes

- It is best case to always follow the notice requirements in the Contract. You will not waive your right to time if you strictly follow the Contract.

- If notice requires an analysis or quantification of delay, provide as much information as available and reserve Clarks rights to additional time or monies when more information becomes available.

- Do not worry about hurting anyone's feelings. You need to protect your interests first.

Dealing with Changes

Understand the Contract requirements for Notice.

Know the timeline. If no timeline is given, serve notice as soon as possible.

Reserve your rights to revise your quantification of both time and money.

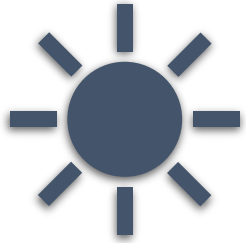
Stick to the facts, refrain from conjecture and inflammatory remarks in notice letters.

Dealing with Changes

- The basic means of forecasting the potential impact of changed work is the development and insertion of fragmentary networks, or “fragnets”.
- Fragnets are simply a chain of activities that represent the change event and associated work.
- The fragnet should be developed when the condition becomes known and then be logically tied into the contemporaneous schedule

Dealing with Changes

Identify and classify types of delays as follows:



Force majeure delay: Any delay event caused by something or someone other than the Owner or the Contractor, If the force majeure delay is on the critical path, in absence of other types of concurrent delays, the Contractor is granted an extension of contract time, classified as a non-compensable event.

A Contractor-delay: Any delay event caused by the Contractor, or the risk of which has been assigned solely to the Contractor. If the contractor-delay is on the critical path, in absence of other types of concurrent delays, Contractor is not granted extension of contract time, and classified as a non-compensable event. Where absent other types of delays, and having impact to project completion, provide a Corrective Action Plan, identifying plan to mitigate delay

An Owner-delay: Any delay event caused by the Owner, or the risk of which has been assigned solely to the Owner. If the Owner-delay is on the longest path, in absence of other types of concurrent delays, the Contractor is granted an extension of contract time, and classified as a compensable event.

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Dealing with Changes

- Carefully monitoring the schedule allows for quickly determining when forecasted completion dates differ from the baseline dates.
- In this respect, progress can be evaluated for whether it has met planned targets.
- Activities may be resequenced or resources realigned. It is also important to determine whether schedule variances are affecting successive work activities.
- A schedule variance may compress remaining activities' durations or cause "stacking" of activities toward the end of the Project, to the point at which it is no longer realistic to predict success.

Dealing with Changes

What can you do

- Adjust the working calendar
- Increase resources
- Perform activities concurrently
- Do nothing

Dealing with Changes

Technique	Description	Side effects
Crashing	Add resources to time-dependent activities to complete work faster	Requires additional resources and thus increases costs; may also reduce quality if activities are executed faster and with less-experienced labor
Fast tracking	Reduce the sequential dependencies between activities to partial dependencies. For example, F–S logic is reduced to S–S logic to force parallel work	Resources may become overallocated; quality may also be reduced and risk introduced if activities ideally executed in sequence are now executed in parallel
Split long activities	Split long activities into shorter activities that can be worked in parallel	Resources may become overallocated
Review constraint and lag assumptions	Reassess assumptions related to forcing activities to begin on certain dates	If the original date constraint or lag is justified, removing the constraint or lag may not be realistic
Review duration estimates	Revisit duration estimates using progress records as actual effort is recorded	
Add overtime and reduce vacations	Review nonworking periods and assign overtime work	Costs will increase over standard labor rates; as overtime increases, morale decreases, eventually affecting the quality of the product negatively
Reduce scope	Decrease scope to reduce both duration and costs	Scope is the primary reason for performing the work, and it may not be possible to delete some requirements
Schedule contingencies	Allocate contingency to absorb delay in accordance with identified risk mitigation plans	Using contingency too early in a project reduces the likelihood of the program's completing on time, particularly if the reason for a delay was a risk that was not previously identified and quantified

AEGIS PROJECT CONTROLS

Measured Mile

- Compares productivity during periods of a project that have been adversely impacted to the productivity levels during periods that were *not* impacted

- “Gold Standard” method of measuring Loss of Productivity (LoP)

- Provides a quantifiable measure of productivity (i.e. units/hour, rooms/week, etc.) to gauge progress
    - Forensically determines how much time and the compensation a contractor is entitled to

Requirements of a Measured Mile Analysis

- Contractors must successfully prove that the LoP is not their responsibility in order to receive additional time and/or money

- Contractors must:
  - Establish entitlement (i.e. that recovery is possible under the contract)
  - Detail how the owner caused the LoP
  - Illustrate the impact/effect of the owner's actions
  - Have detailed and accurate records for measurement
  - Convert Loss of Productivity into a monetary amount

How to Perform an Effective Measured Mile

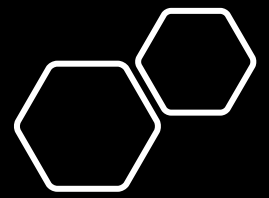
- Comparison of impacted to non-impacted periods must be comparable
  - Same scope/type of work
  - Unimpacted area must be representative
  - Generally same crew type (i.e. same skill level)

- Comparison based on actual production rates; NOT estimated rates

Week	Impacted / Unimpacted	Weekly Production pieces	Cumulative Production pieces	Δ Unimpacted vs Impacted	Cost/Piece: $100
1	Unimpacted	10	10	0	
2	Unimpacted	10	20	0	
3	Unimpacted	10	30	0	
4	Impacted	7	37	-3	$300.00
5	Impacted	8	45	-2	$200.00
6	Impacted	6	51	-4	$400.00
7	Impacted	6	57	-4	$400.00
8	Impacted	7	64	-2	$300.00

Total Pieces Lost:	Loss of Productivity:
16	$1,600.00

Measured Mile Example



No Damages For Delay

- Clause in a contract that waives claims for additional compensation for delays on project
  - This clause represents substantially increased financial risk to the Contractor
- Although rare, this section in a contract establishes that all delays, even those *not* the fault of the contractor, will not be compensable
  - May award time, but not money
- When presented with this clause a contractor must decide:
  - Should they bid it
    - This is a highly non-collaborative contract
  - Evaluate the risk premium they add to the bid amount

No Damages For Delay - Sample

G. Delays and Extensions of Time: Except as otherwise specifically provided, the CONTRACTOR shall not be entitled to payment or compensation of any kind from COUNTY for direct, indirect or impact damages including, but not limited to, costs of acceleration, arising because of hindrance or delay from any cause whatsoever, whether such hindrance or delay be reasonable or unreasonable, foreseeable or unforeseeable or avoidable or unavoidable; provided, however, that this provision shall not preclude recovery by CONTRACTOR of damages for hindrances or delays due solely to fraud or bad faith on the part of COUNTY. CONTRACTOR shall be entitled to extensions in the time required for performance of the Work only as specifically provided in the Contract Documents.

- Not all states in the US allow this clause
  - Above example is an attempt to circumvent law

No Damages for Delay

"No claims for increased costs, charges, expenses or damages of any kind shall be made by the Contractor against the Owner for any delays or hindrances from any cause whatsoever; provided that the Owner, in the Owner's discretion, may compensate the Contractor for any said delays by extending the time for completion of the Work as specified in the Contract."

"Should the Contractor sustain any damage through any act or omission of any other contractor having a contract with the Owner or through any act or omission of any Subcontractor of said other contractor, the Contractor shall have no claim against the Owner for said damage."

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No Damages for Delay

The clause is written to reject liability for delay caused by specific events unanticipated at the time of contracting. This includes but is not limited to:

Delay in required right-of-way	Delay in obtaining owned or furnished materials	Potential delay that might be caused by other contractors working on the same project	Delay due to changes in scheduling or sequencing of the work	Delay due to underground obstructions	Delay due to utility relocations

The purpose of a “No Damage for Delay” clause is to allocate risk of delay between the parties, since the cost of delays may be difficult, if not impossible, to measure at the time of contracting.

No Damages for Delay

Review your contract for these types of provisions and try to negotiate the terms.

If an owner is unwilling to remove a no-damages-for-delay clause in your contract, then you should try to limit its application to certain delays such as delays caused by others, leaving the owner liable for its own delays.

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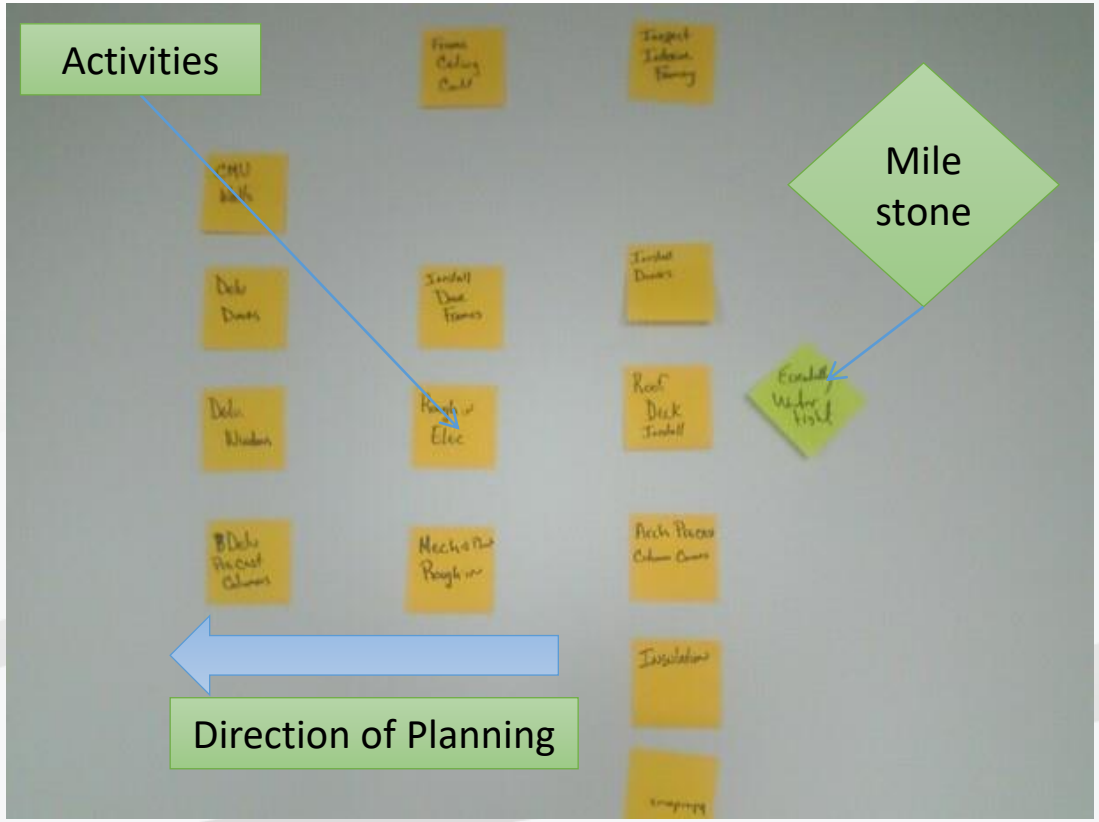
Coordination with Others

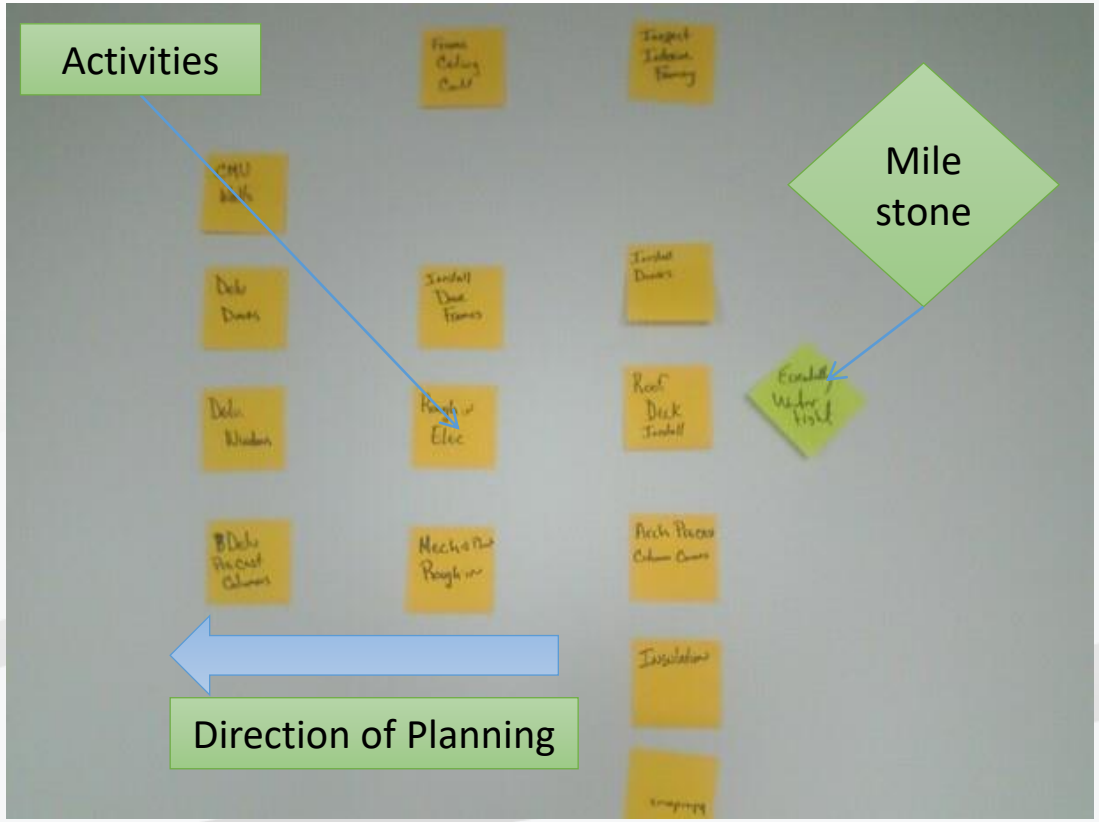
What is Pull Planning?

- Aims to create a continuous flow of work and eliminate waste
- Eliminates the “top down” approach and creates a conversation
- Change your thinking from “what can I do after this activity” to “what absolutely needs to be done before I can perform this activity”



What is Pull Planning?

- Work only occurs when the next production unit requests it
  - Material being delivered to site only when the site is ready to receive it
- Planning is about having a conversation, not evaluating performance



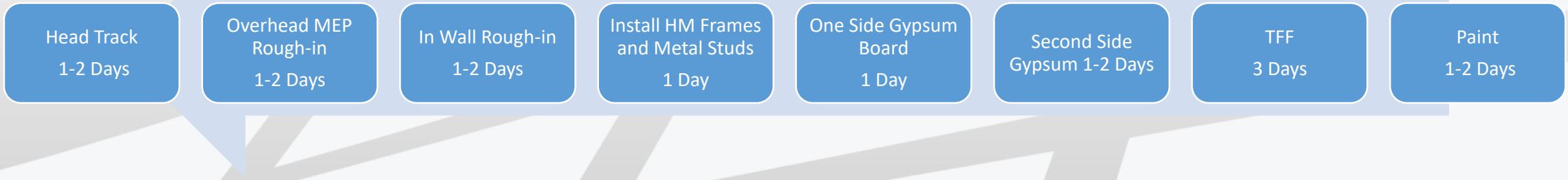
Why use Pull Planning?

- If the project does not have a master schedule
- If you have received a schedule and need to incorporate your scope of work
- If your scope of work is slipping and needs to be mitigated
- If you need to accelerate your work to meet the general contractor’s plan

Collaboration

Project Level Discussions:

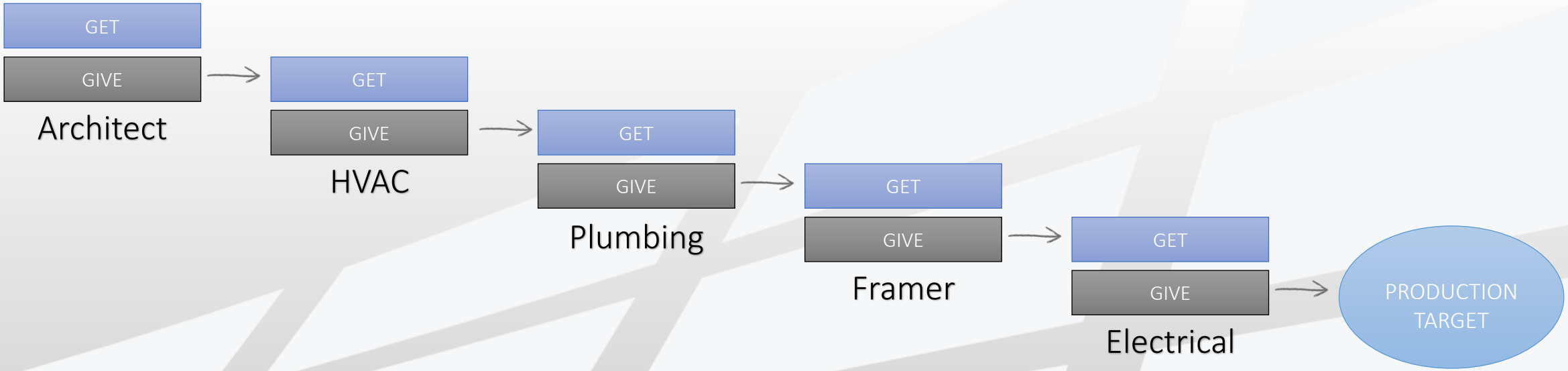
- What are the gets/gives
- Expected production rates
- What are the handoffs
- The conditions of satisfaction
- Is this the right order?
- Should it be built another way?
- Should these elements be broken down further?



Collaboration

Participants:

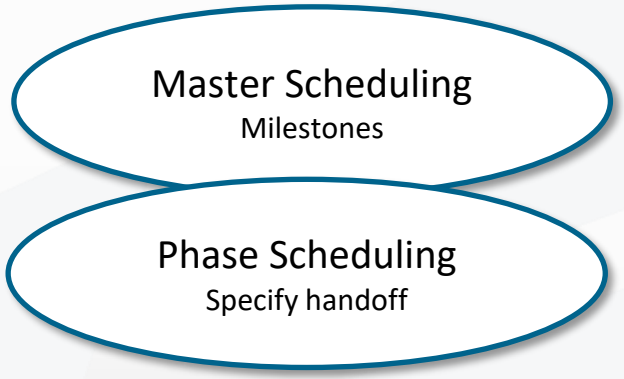
- Superintendent for GC
- Subcontractor foreman able to direct manpower
- Suppliers
- Owner / Architect (Contract permitting)



Levels of LPS

Key points to identify in each phase:

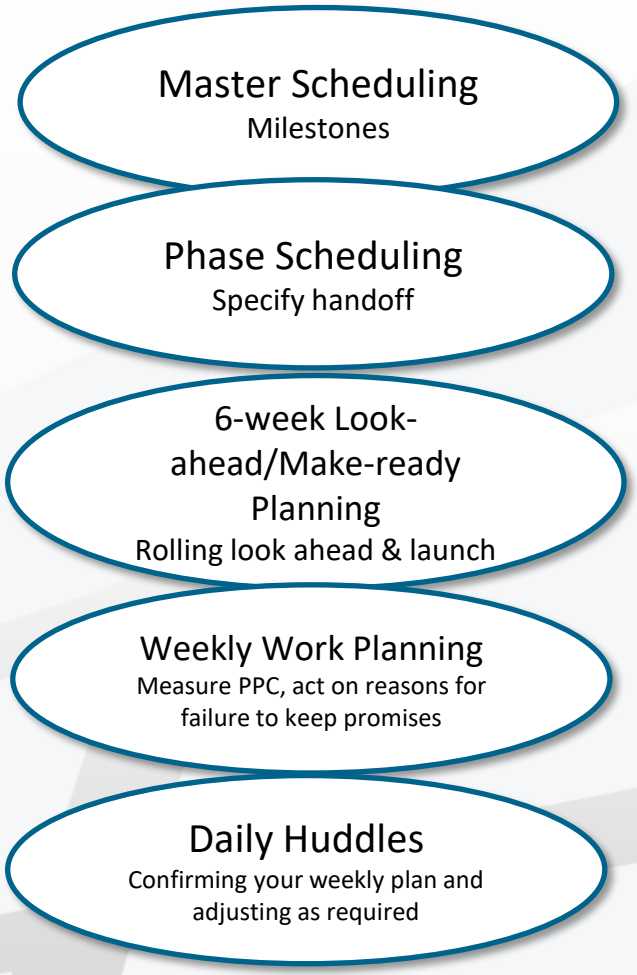
- Milestones: Important interim goals that give us confidence that we will complete the project
- Phase: For each milestone, create a plan for getting to that milestone



Levels of LPS

Key points to identify in each phase:

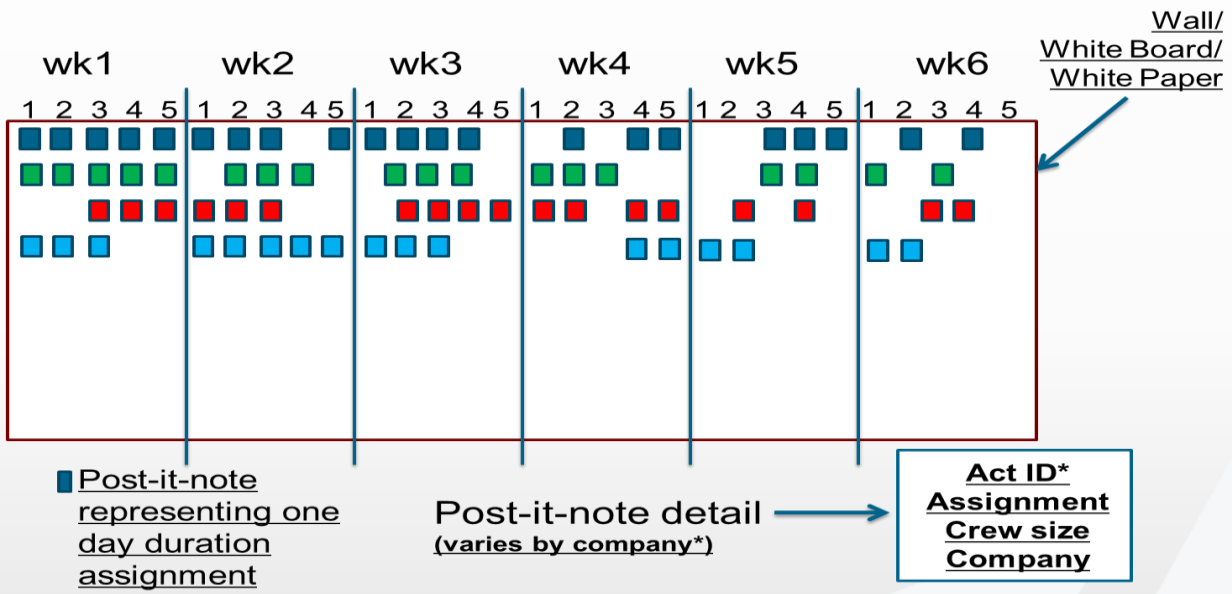
- Make-Ready Plan: Removing constraints from “shoulds” results in determining what “cans” be done; eventually matching “shoulds” to “cans”.
- Weekly Work Plan: A list of assignments to be completed in a specific week; creating the “will”.
- Daily Huddle: A meeting that takes place every morning to discuss our daily “will”.

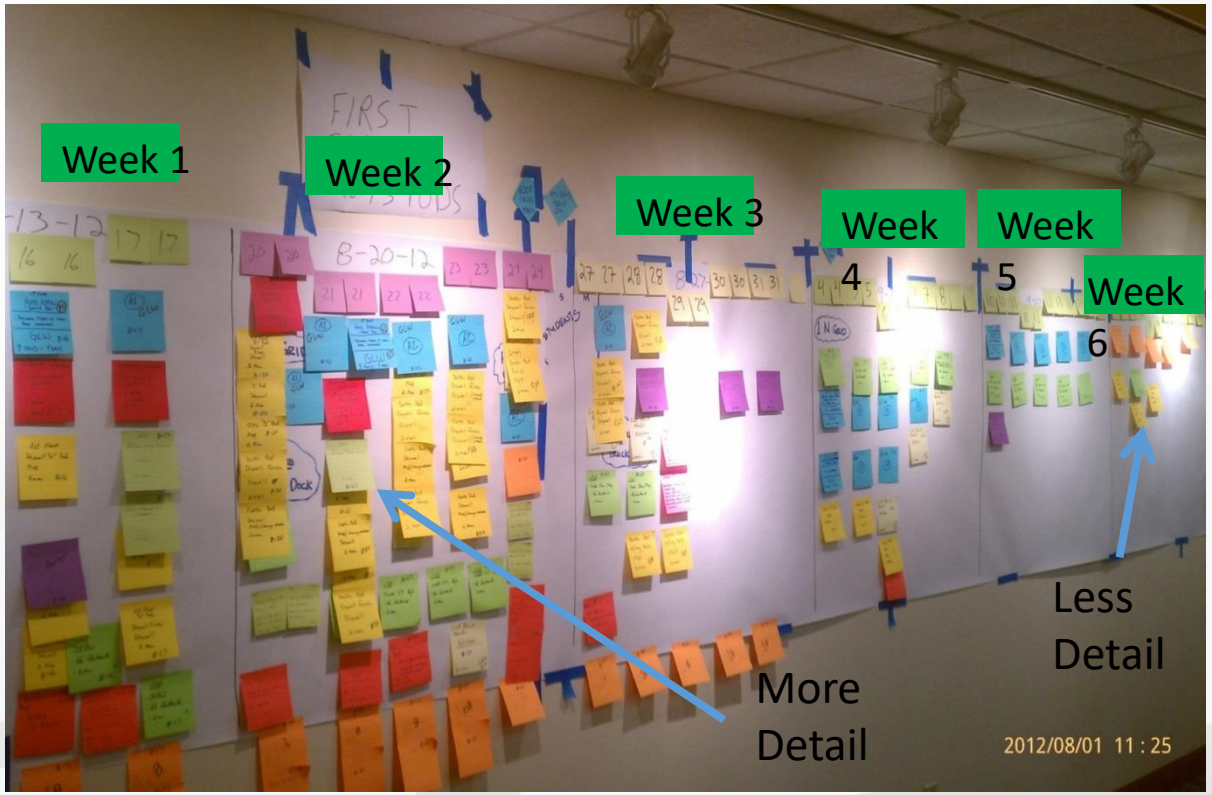


Goal of the Make-ready process

- Shape workflow sequence and rate
- Define constraints
- Match workflow and capacity
- Maintain a backlog of ready work
- Develop detailed plans for how work is to be done
- Address safety, environmental, and quality issues

Make-ready Planning Board





		October - Week 2							
Activity	**Sub.**	**M**	**T**	**W**	**Th**	**F**	**Complete**	**Reason**	**Notes**
Area A									
Mech Trim - Start	Mech						No	Manpower	Journeyman called in sick
Area B									
Grid	Ceiling						Yes		
Mech Trim	Mech						Yes		
Plumbing Trim	Plbg						Yes		
Area C									
Elec Trim	Elec						Yes		
Plumbing Trim	Plbg						No	Material	Late on W.; pushed activity completion to Th.
Area D									
Prime	Painter						Yes		
Grid	Ceiling						Yes		

Weekly Work Planning

- Identify work in the “will” phase
- Last Planner’s commitment is key

Daily Huddle

- Foreman and superintendent all come together as a group
  - Keep it brief and on target
- Each foreman should review:
  - Yesterday's accomplishments
  - Today's workplan and manpower
  - Indicate (on the plans) where their crew(s) will be doing work
  - Recently discovered constraints
  - Today's material delivery

How to Mitigate Variation

- Create buffers
  - Inventory buffers – maintain excess materials on site
  - Capacity buffers – build in reserve capacity in a crew
  - Schedule buffers – work not on the critical path that acts as a backup for planned work left
- Reducing buffers
  - Eliminating these safety nets allows us to identify what the true problems in out system are and work on ways to mitigate them, creating a more effective system
- Use the combined knowledge of a larger portion of your team to explore alternative solutions

Best Practices

- Use measurable activities
- Every handoff of work must be direct and understandable
- There must be a clear path for work to be completed with all directives, prerequisites and resources complete

Short Interval Plan Schedule (SIPS)

Lookahead Schedules

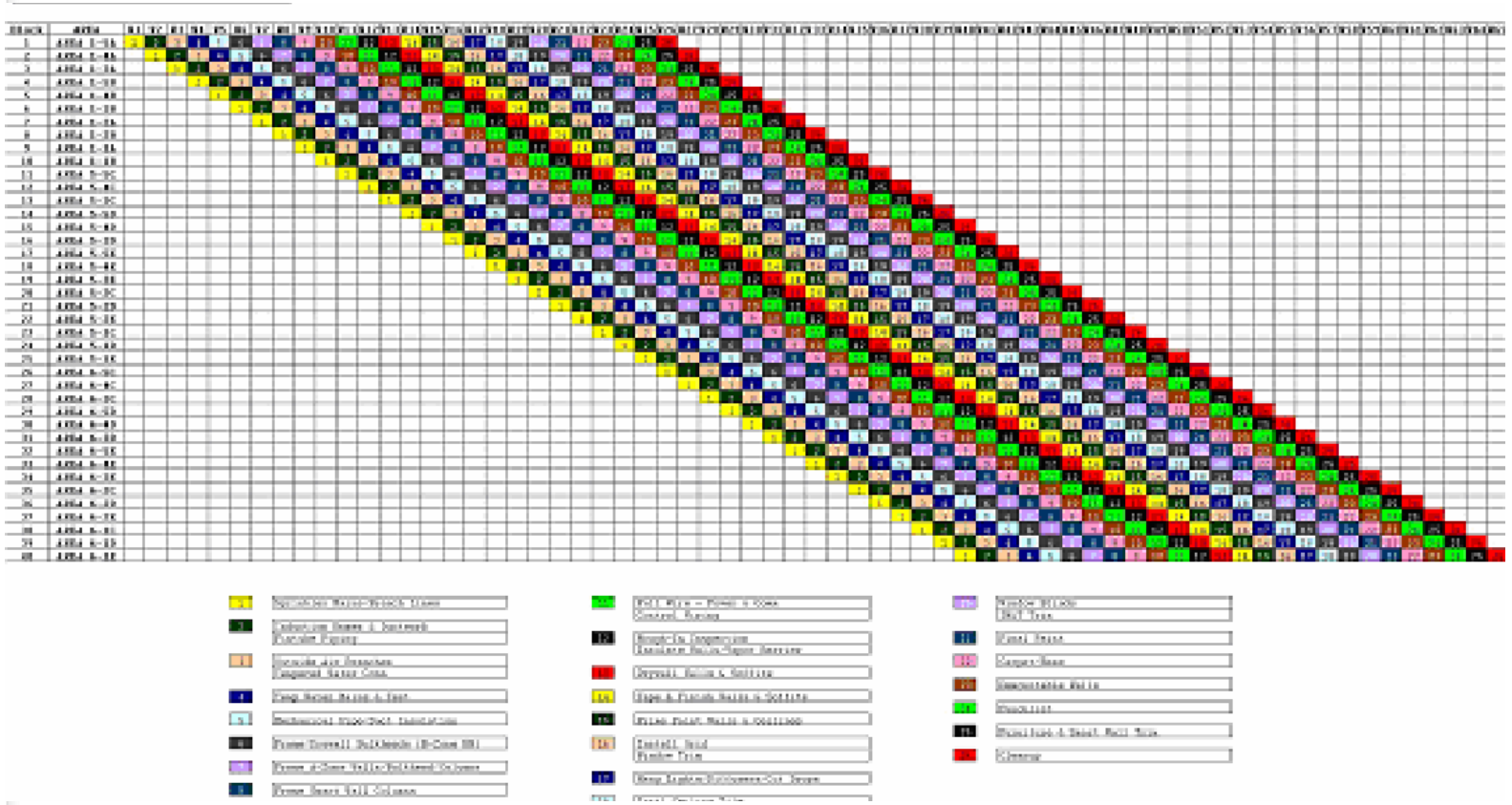
Short Interval Plan Schedule (SIPS)

A SIPS is developed to detail the day-to-day production or task-to-task production during any repeatable construction project

It details scheduling at the crew level

SIPS can be beneficial for a project that has highly repeatable activities, such as apartments, hotels, office buildings

Typically, these projects will have a standardized interior floor or wing layout that makes the use of a SIPS desirable.



Short Interval Plan Schedule (SIPS)

- There are three main ideas that differentiate SIPS from other scheduling methods:
  - Only one major specific operation is detailed
  - A higher level of detail is developed then typically seen
  - There must be personnel involvement and commitment from everyone contributing to the operation
- There are four steps that need to be taken to develop a SIPS:
  - Break the operation into specific activities
  - Assign production rates to each activity
  - Calculate extensions and set goals
  - Develop a time-scaled, resource loaded bar chart

AEGIS
PROJECT CONTROLS

Short Interval Plan Schedule (SIPS)

- SIPS improves productivity and reduces labor waste.
- SIPS helps supervisors to identify actual work done vs. what was planned, to evaluate constraints and opportunities
- SIPS helps manage labor, tools and materials needed for a day and identify drivers of waste and rework.

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PROJECT CONTROLS

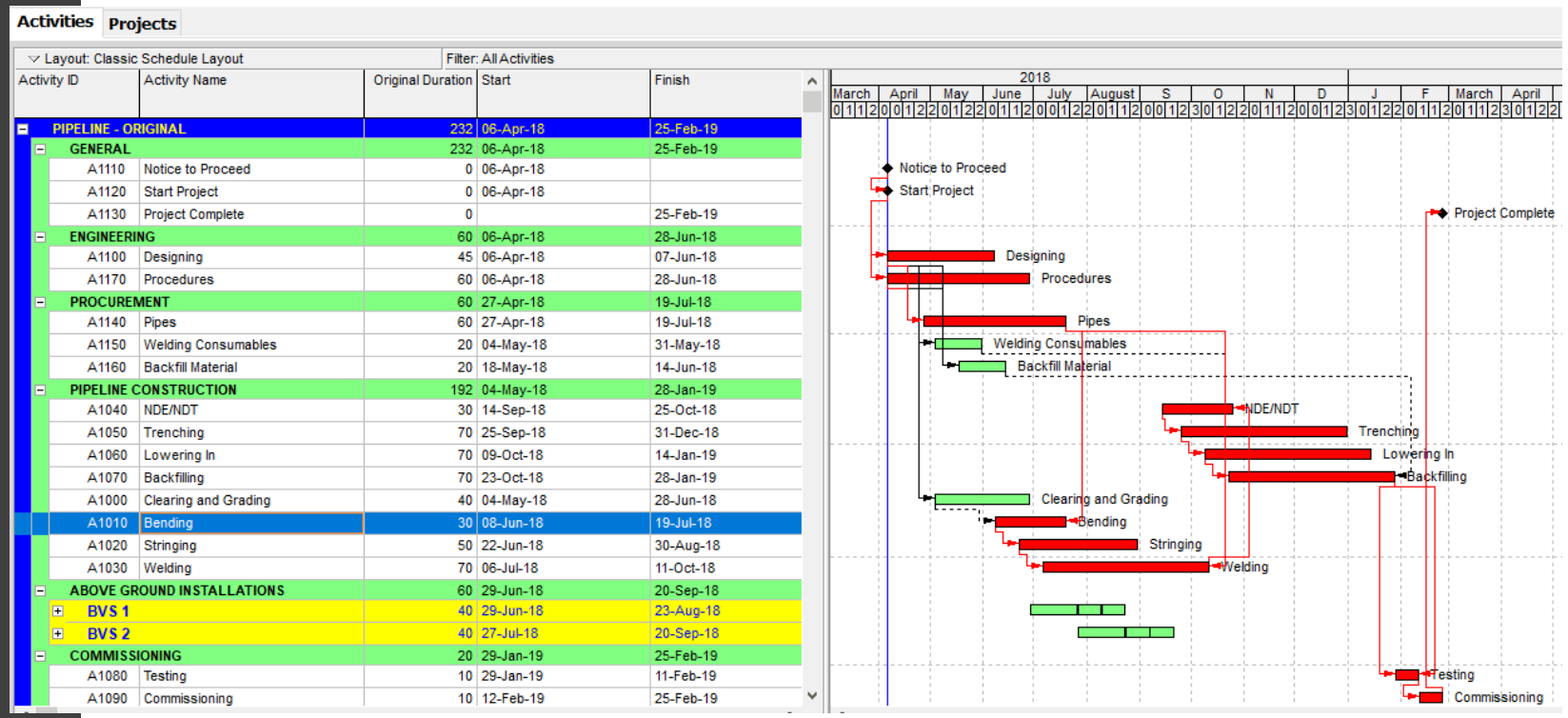
Short Interval Plan Schedule (SIPS)

- SIPS breaks it down one step further into the tasks associated with the WBS
  - When it's going to be done
  - Who is going to do it
  - Performance measures associated with each task.
- A Work Breakdown Structure and SIPS can work together to break huge projects into manageable tasks, keeping the overall project on track.

AEGIS
PROJECT CONTROLS

Lookahead Schedules

- When a schedule is created and the baseline is assigned, the project team starts to track the performance in order to report the variances between planned and the actuals.
- Review the work performed to compare the planned and the actual dates and look ahead reports recognizing the near future tasks to be performed.
- Lookahead reports show the activities to be performed in the next three or four weeks.



AEGIS PROJECT CONTROLS

Lookahead Schedules

The purpose of the three week look ahead schedule is to plan the activities and goals of the project for the next three weeks.

The overall schedule is used to create look ahead schedules.

Three week look ahead schedules are the tools which are commonly used for the weekly job progress meetings.

Plan resource allocation plans and take actions to stick to the schedule.