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THE PATH FROM GOOD PROJECT SCHEDULING TO IMPLEMENTING ADVANCED WORK PACKAGING

Chris Carson, FRICS, FAACE, FGPC

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Chris Carson, FRICS, FAACE, FGPC

Director of Program & Project Controls, Vice President, ARCADIS

Experience: Over 45 years of experience in Facilities, Educational Facilities, Dorms/Condos/Hotels, Medical, Labs, Retail Restaurant, Museum, Military construction, Industrial, Energy, Port/Terminal, Transit/Light Rail/Heavy Rail, Infrastructure Road/Bridge, Parking Garage, in Program & Construction Management, Controls, Forensic Analysis/Dispute Resolution

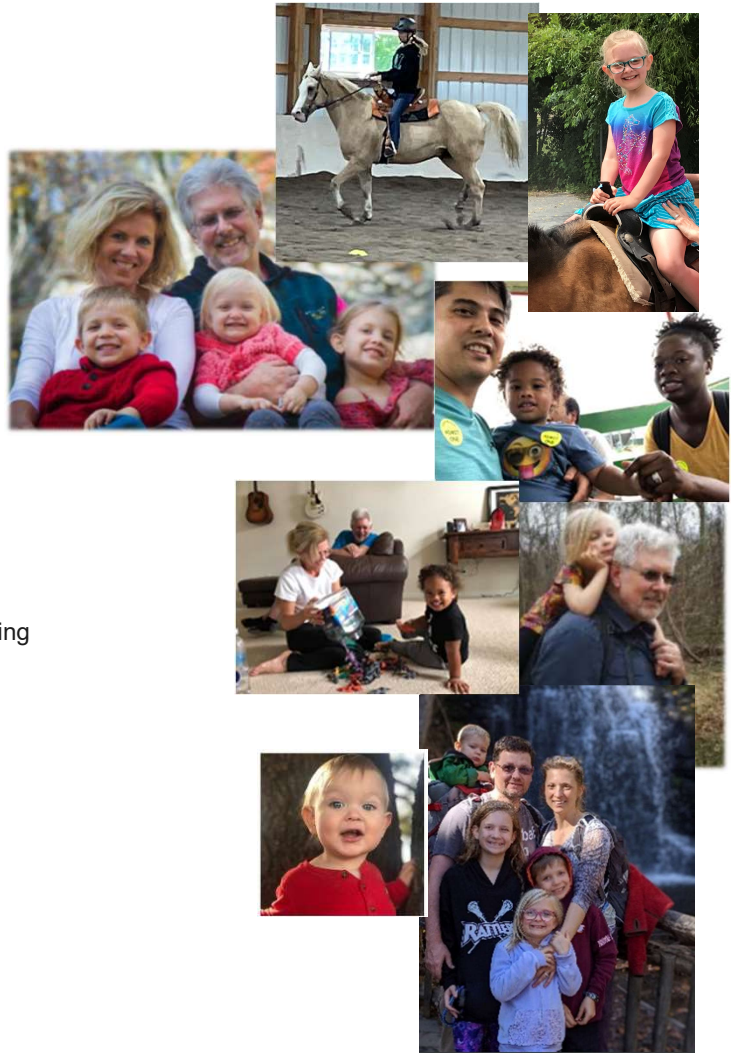
Certifications:

- AACE International – PSP, CEP, DRMP (Scheduling, Cost, Risk certifications)
- CMAA - CCM (Certified Construction Manager)
- PMI - PMP (Project Management Professional)
- RICS - Chartered Surveyor

University of Virginia, Mechanical Engineering, 1972

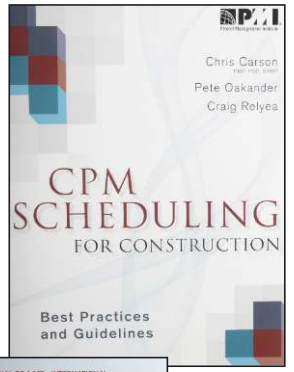
Fellowships and Awards

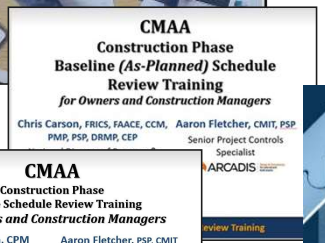
- 2021 AACE International “O.T. Zimmerman Founder’s Award” for significant continuous contributions to Cost Engineering
- 2015 Fellow & Chartered Surveyor by RICS (Royal Institution of Chartered Surveyors)
- 2014 Fellow of Project Controls by the Guild of Project Controls
- 2013 Fellow by AACE International
- 2011 AACE International “Technical Excellence Award”
- 2009 PMI College of Scheduling “Significant Contributions to The Scheduling Industry” award
- 2006 CMAA “Chairman’s Award” for contributions to CMAA and the Construction Management profession



Chris Carson, PSP, DRMP, CEP, CCM, PMP

- **OVER 70 PUBLICATIONS:**
  - PMI book, "CPM Scheduling for Construction - Best Practices and Guidelines"
  - CMAA Guidelines contributor – Time & Claims Management
  - AACE Recommended Practices, Journal articles in Scheduling, Risk, Cost, Forensic Analysis – Recovery Scheduling, Identifying the Critical Path
  - Two articles published in 2021 AACE publications
- **OVER 700 SEMINARS/TRAINING/PRESENTATIONS**
  - Project Control Academy Forensic Schedule Delay Analysis Course





Agenda

What is Advanced Work Planning (AWP)?

Why is AWP Valuable?

How Can CPM Scheduling Evolve into AWP?

Does the AACE TCM Framework Support AWP?

Lessons Learned to Start on the Path to AWP

What is Advanced Work Planning (AWP)

What is Advanced Work Planning (AWP)?

Process

- Structured process for planning and execution
- Aligns engineering, procurement, and construction
- Focuses on early planning
- Brings traditional workface planning into early phases
- Not just construction level planning
- Studied formally by the Construction Industry Institute (CII)
  - With Construction Owners Association of Alberta (COAA)
  - Tested and refined by industry formal research projects
  - Owner, Contractor, and Consultant organizations participation

From: “Validating Advanced Work Packaging as a Best Practice”, by CII/COAA

What is Advanced Work Planning (AWP)?

Process

- Provides three primary deliverables across the project lifecycle:
  - Construction Work Packages (CWP)
  - Engineering Work Packages (EWP)
  - Installation Work Packages (IWP)
- Provides framework for execution
- But execution plan provides guidance

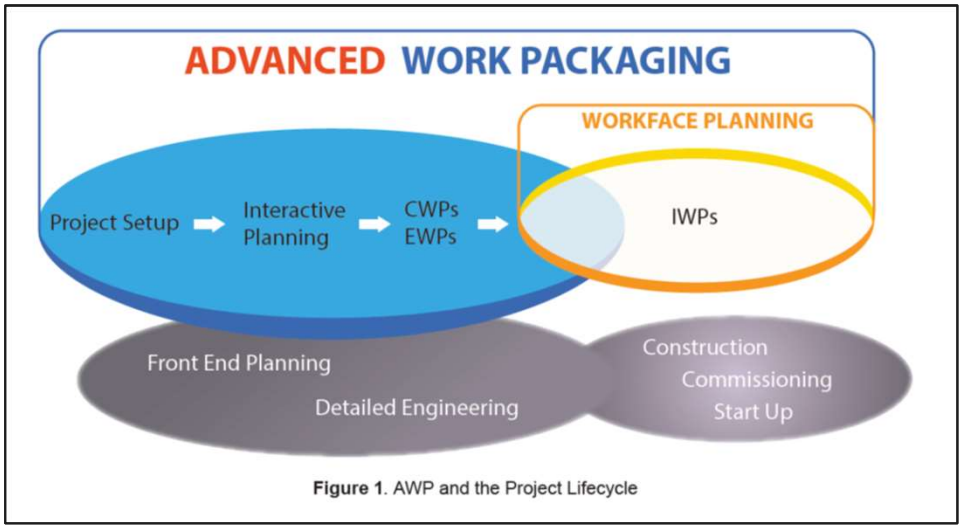


Figure 1. AWP and the Project Lifecycle

From: "Making the Case for Advanced Work Packaging as a Standard (Best) Practice", by CII

What is Advanced Work Planning (AWP)?

Process

- Formal AWP requires changes to preliminary design, detailed engineering, and construction

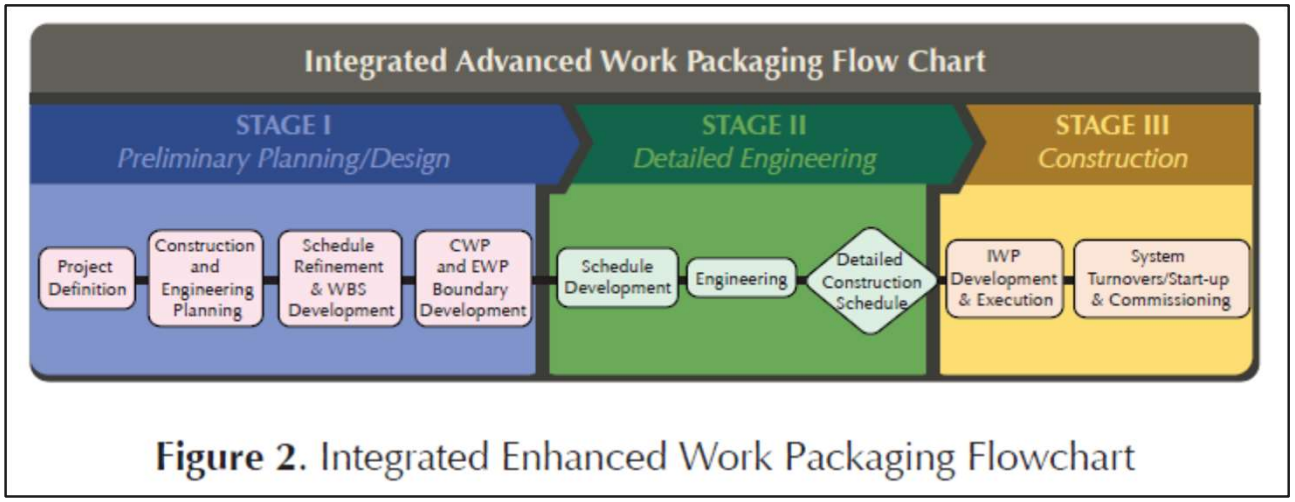


Figure 2. Integrated Enhanced Work Packaging Flowchart

From: "Advanced Work Packaging: Design through Workface Execution", by CII

What is Advanced Work Planning (AWP)?

Process

- Construction focus is on work packages

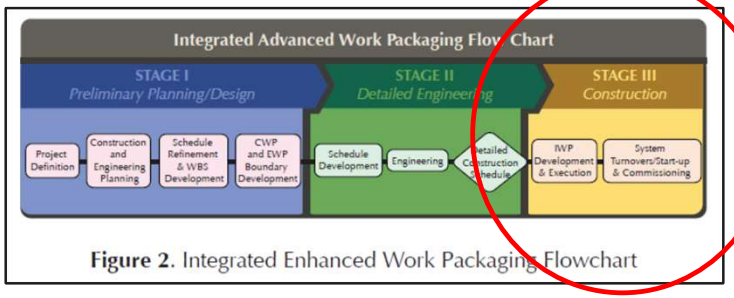


Figure 2. Integrated Enhanced Work Packaging Flowchart

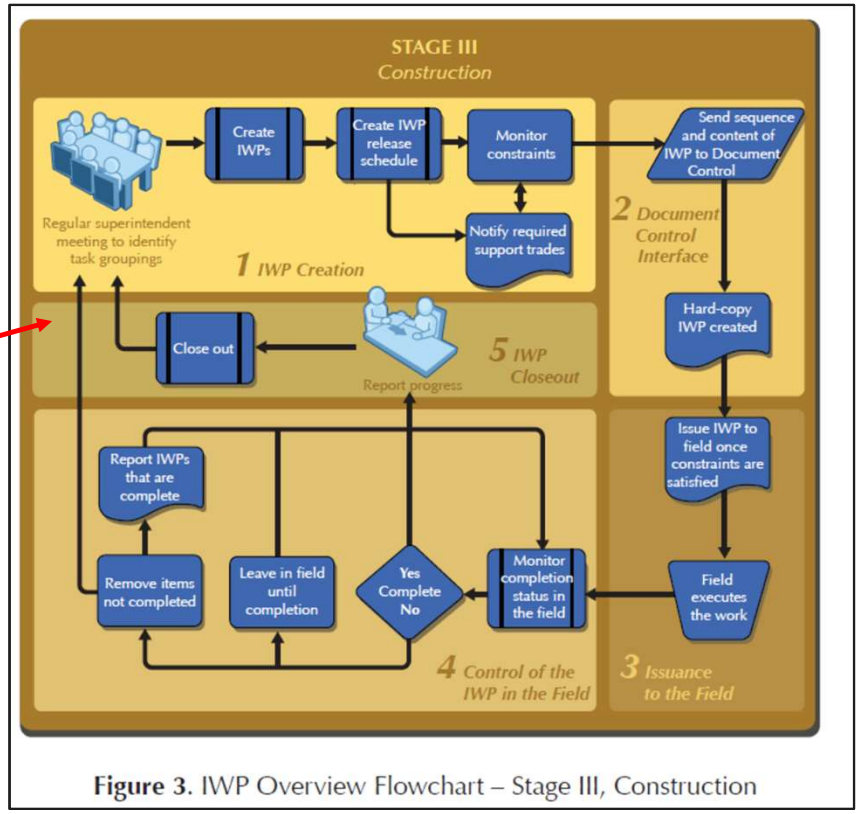


Figure 3. IWP Overview Flowchart – Stage III, Construction

From: "Advanced Work Packaging: Design through Workface Execution", by CII

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Why is Advanced Work Planning (AWP) Valuable?

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Why is AWP Valuable?

Proven Process

- Academically rigorous research
- Established an "AWP Maturity Model"
  - Identified three stages of implementation

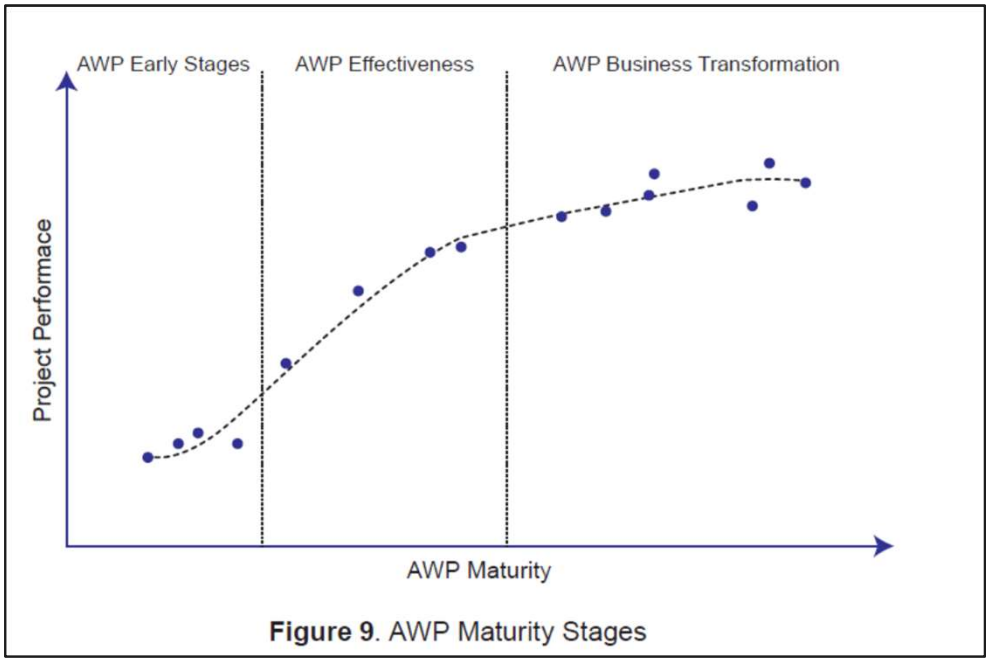


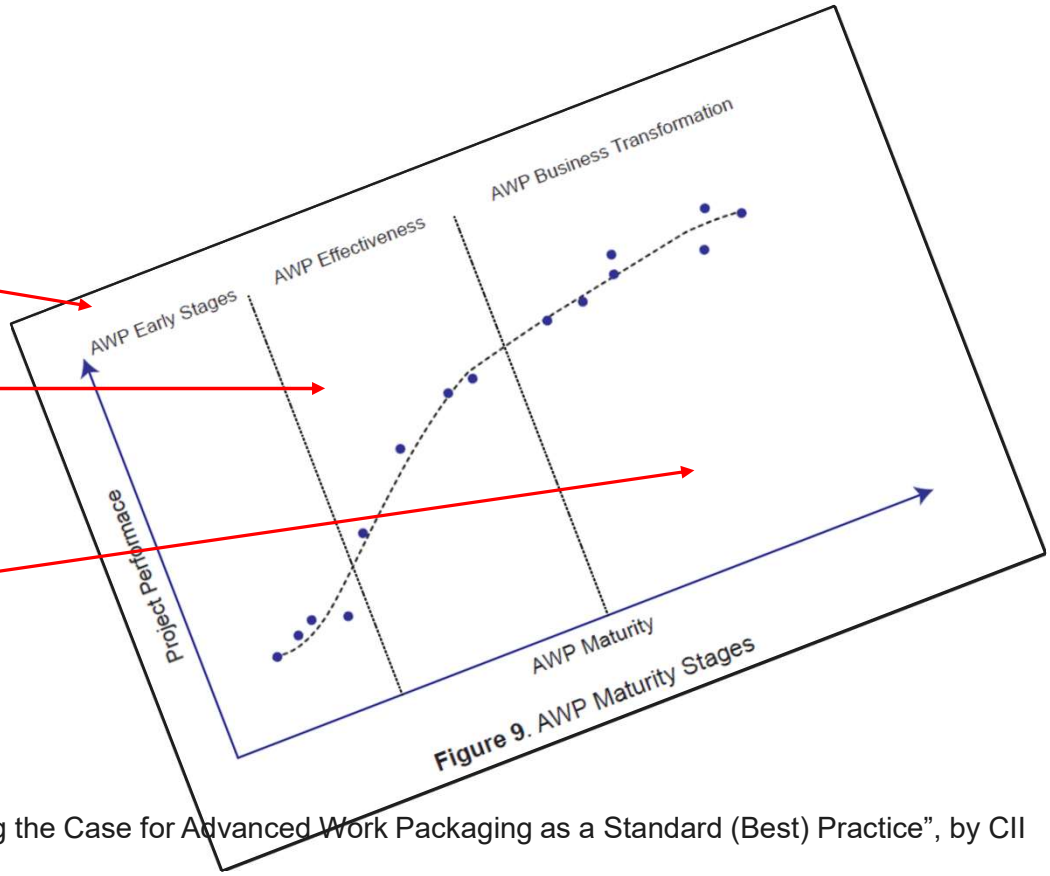
Figure 9. AWP Maturity Stages

From: "Making the Case for Advanced Work Packaging as a Standard (Best) Practice", by CII

Why is AWP Valuable?

AWP Maturity Model

- Each stage showed performance improvements
  - AWP Early Stages
    - Field productivity
    - Cost improvements
    - Safety improvements
  - AWP Effectiveness
    - Productivity
    - Cost
    - Safety
    - Schedule
  - AWP Business Transformation
    - Quality
    - Predictability



From: "Making the Case for Advanced Work Packaging as a Standard (Best) Practice", by CII

Why is AWP Valuable?

AWP Maturity Model

- Documented performance

Table 2. AWP Maturity Stages and Project Performance

	Maturity Stage		
Performance Dimension	**1. AWP Early Stage**	**2. AWP Effectiveness**	**3. AWP Business Transformation**
Productivity	Around 10% increase	Around 25% increase	Around 25% increase
Cost	Project on budget	TIC 10% below estimates	TIC 10% below estimates
Safety	Zero lost time incidents (TRIR below company average)	Zero lost time incidents (TRIR improves with sporadic first-aids and near misses.)	Zero lost time incidents (TRIR improves with sporadic first-aids and near misses.)
Predictability	Significant deviation from baseline estimates	Minor changes to execution schedule	Execution schedule to plan
Quality	Rework in line with previous quality performance	Rework slightly below company's average	Rework substantially below company average; substantial reduction of RFIs
Schedule	Project on schedule or experienced minor delay	Project slightly ahead of schedule during execution	Project slightly ahead of schedule during execution

From: "Making the Case for Advanced Work Packaging as a Standard (Best) Practice", by CII

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How Can CPM Scheduling Evolve into AWP?

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CPM Scheduling Maturity Needed

AWP requires reasonable maturity in planning & scheduling

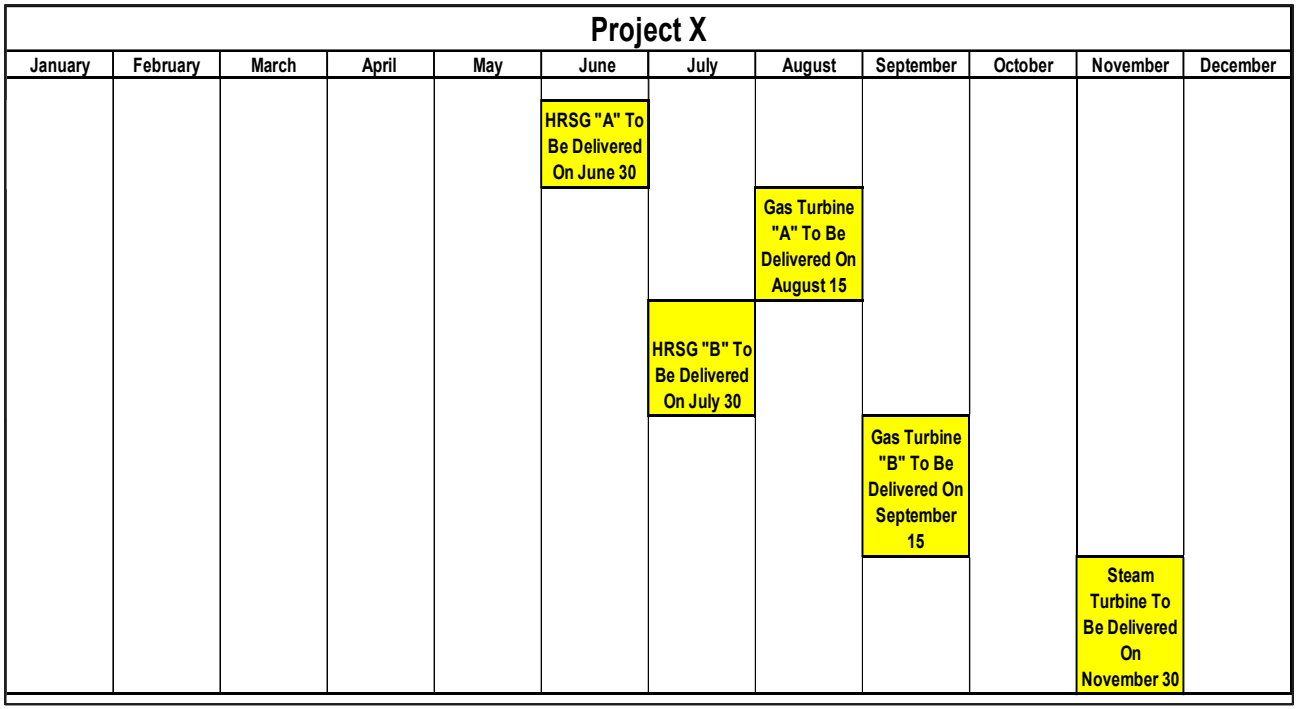
- Typical early-stage planning is not detailed enough to support AWP
- Scheduler must understand sequencing needs
- Scheduler needs detailed construction team input

- Embracing AWP takes a fully collaborative planning and scheduling effort

- On even complex projects, good CPM scheduling is the predecessor to AWP

CPM Scheduling Maturity Needed

Start with delivery of long lead time equipment or erection sequences in a planning session



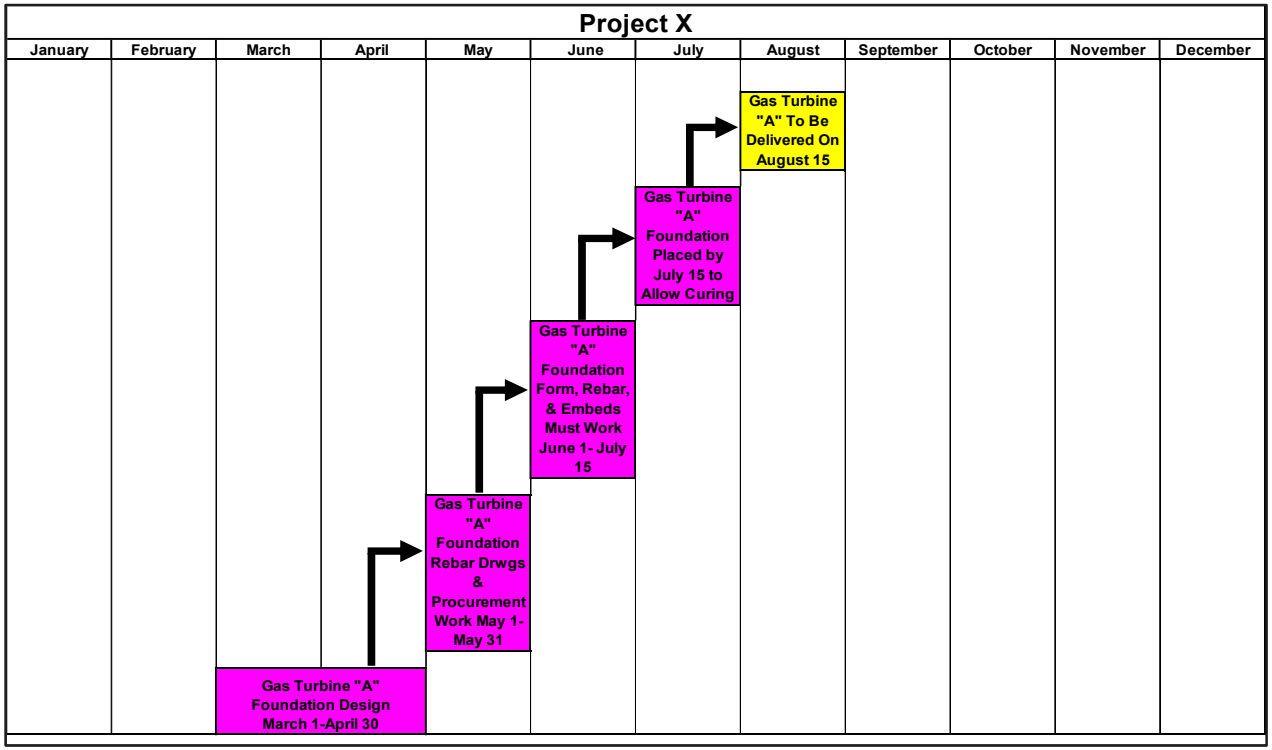
CPM Scheduling Maturity Needed

The next step of the planning session

- Perform a backward pass through the foundation engineering for each piece of equipment
- This should include cure time, winter concrete placing, rainy season allowance, etc.
- If the equipment is inside a building, then the building foundation and slab may need to be placed prior to the equipment foundation
- Building close-in at equipment locations may drive another path of activities or sequencing
- Access paths may drive sequencing – elevator shaft drilling, modular construction installation

CPM Scheduling Maturity Needed

This backwards pass step identifies the appropriate sequencing needed, enabling the transition to formal Advanced Work Packaging



CPM Scheduling Maturity Needed

The next part of the planning session

- Next, set the equipment on foundations and go forward through construction
- This same process is then continued through all major equipment, structures and commodities through system turnover
- If the project is not driven by equipment deliveries, then pick the important milestones and use the same planning approach

If this CPM scheduling process is already followed, adoption of AWP is much simpler

- Sequencing is established as necessary for AWP

CPM Scheduling Maturity Needed

Similar process for erection sequences – field installation dictates sequences used in planning

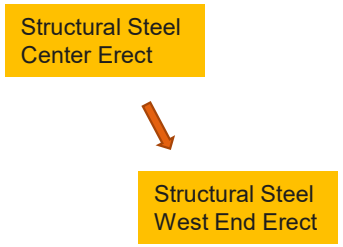
Project X											
January	February	March	April	May	June	July	August	September	October	November	December

Structural Steel
West End Erect

CPM Scheduling Maturity Needed

Similar process for erection sequences – field installation dictates sequences used in planning

Project X											
January	February	March	April	May	June	July	August	September	October	November	December



CPM Scheduling Maturity Needed

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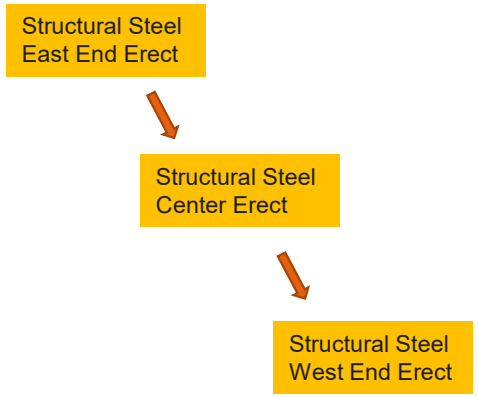

CPM Scheduling Maturity Needed

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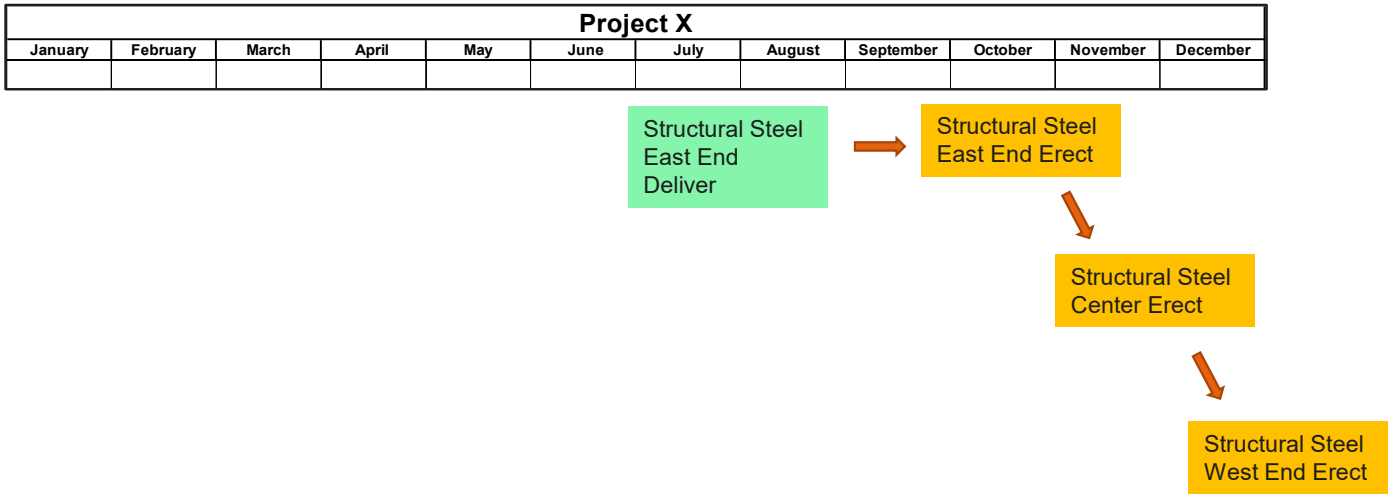

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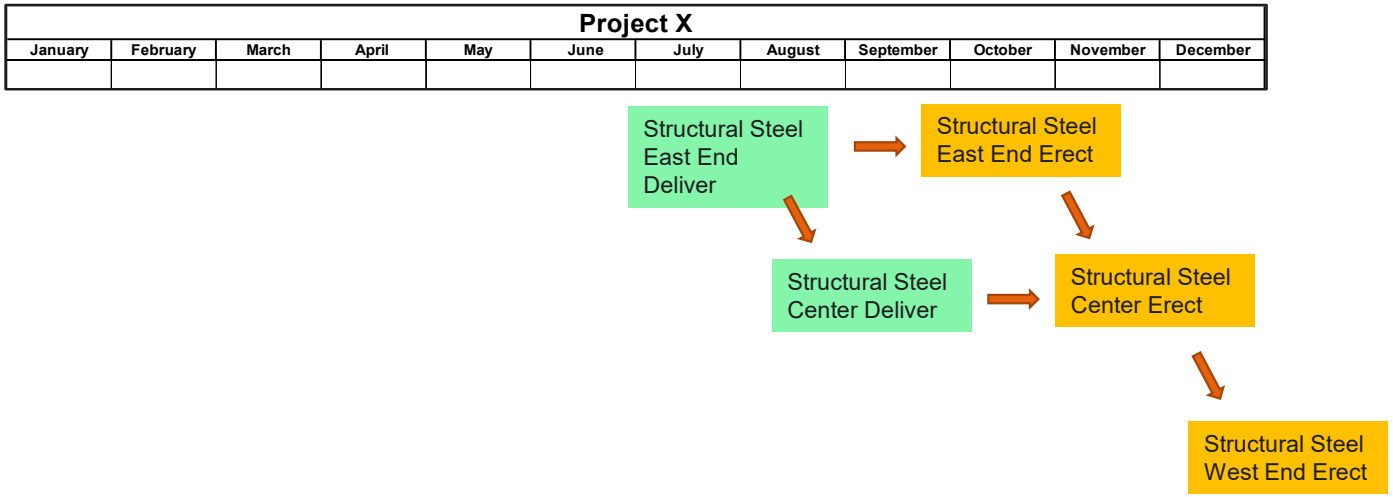

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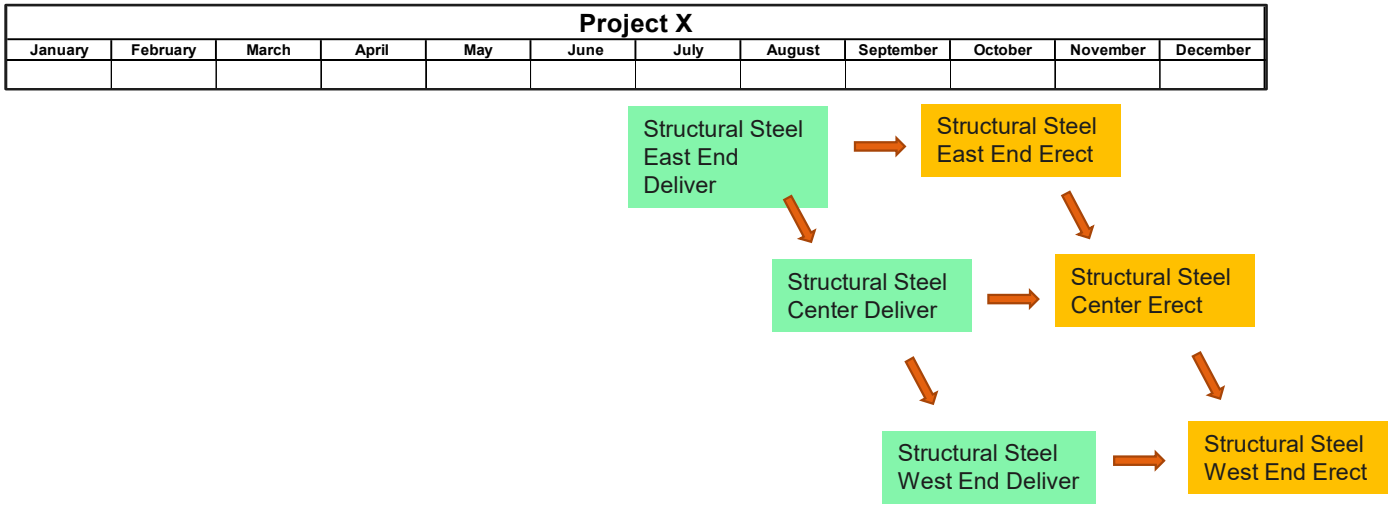

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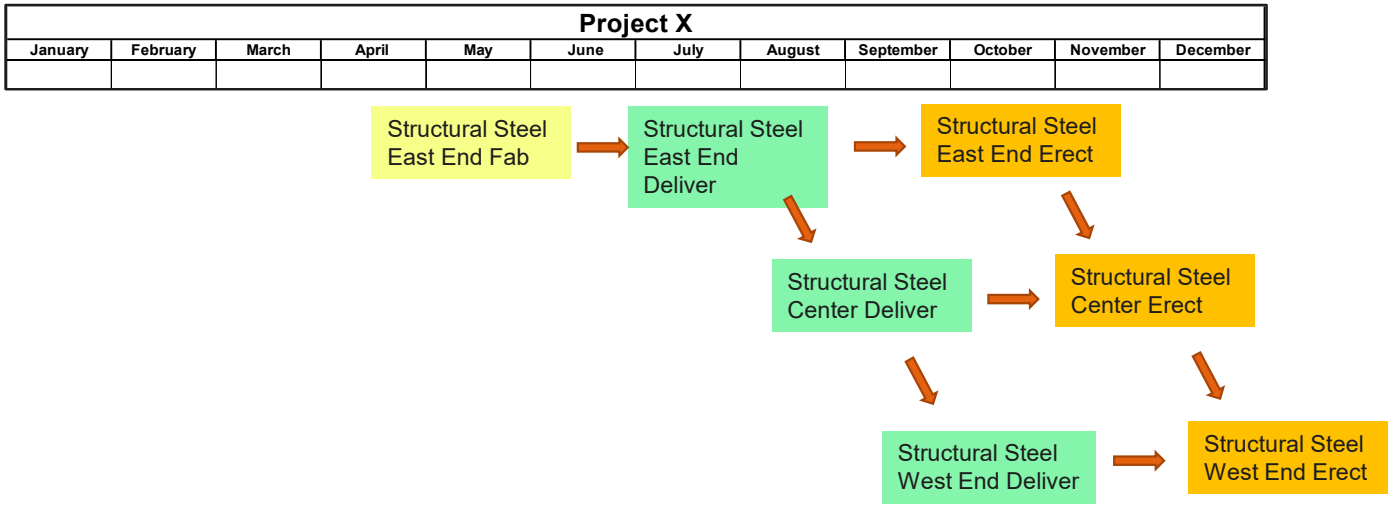

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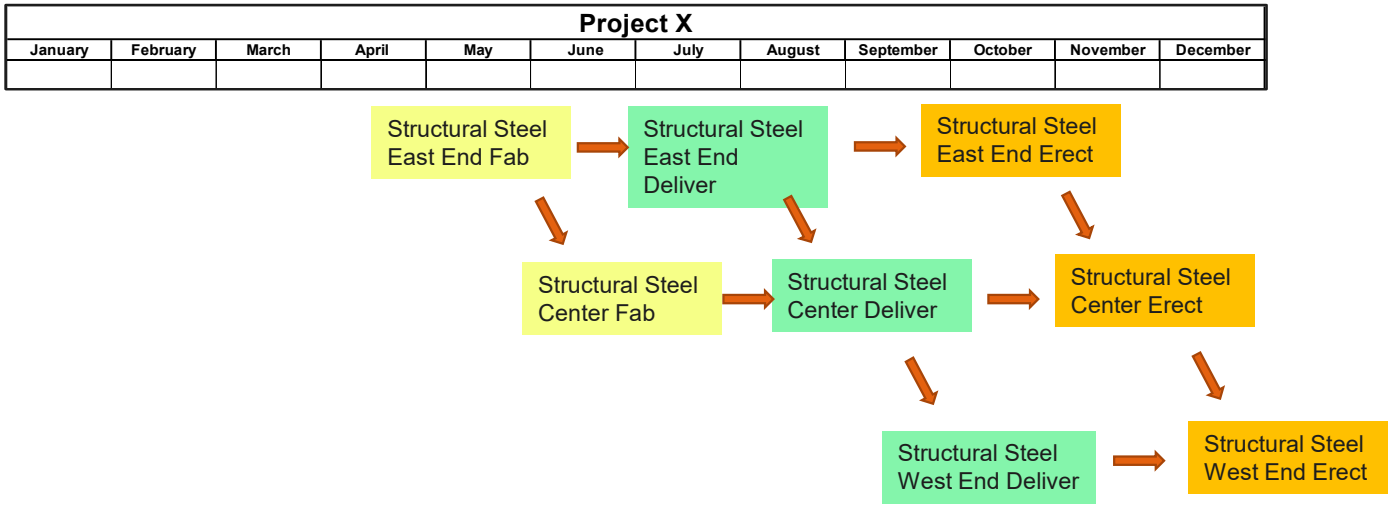

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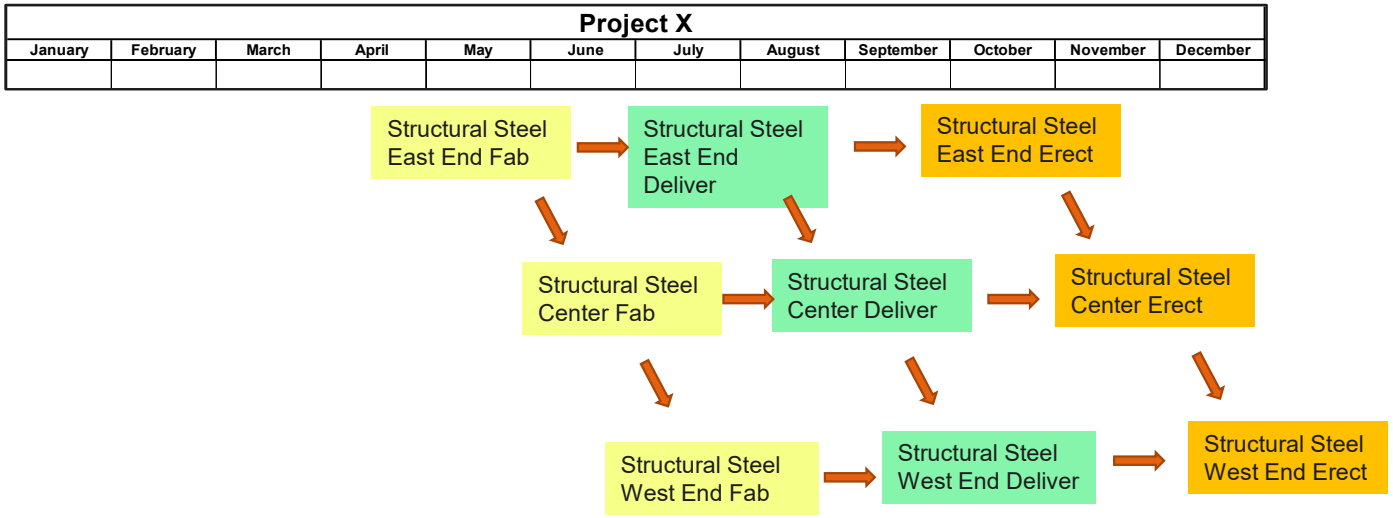

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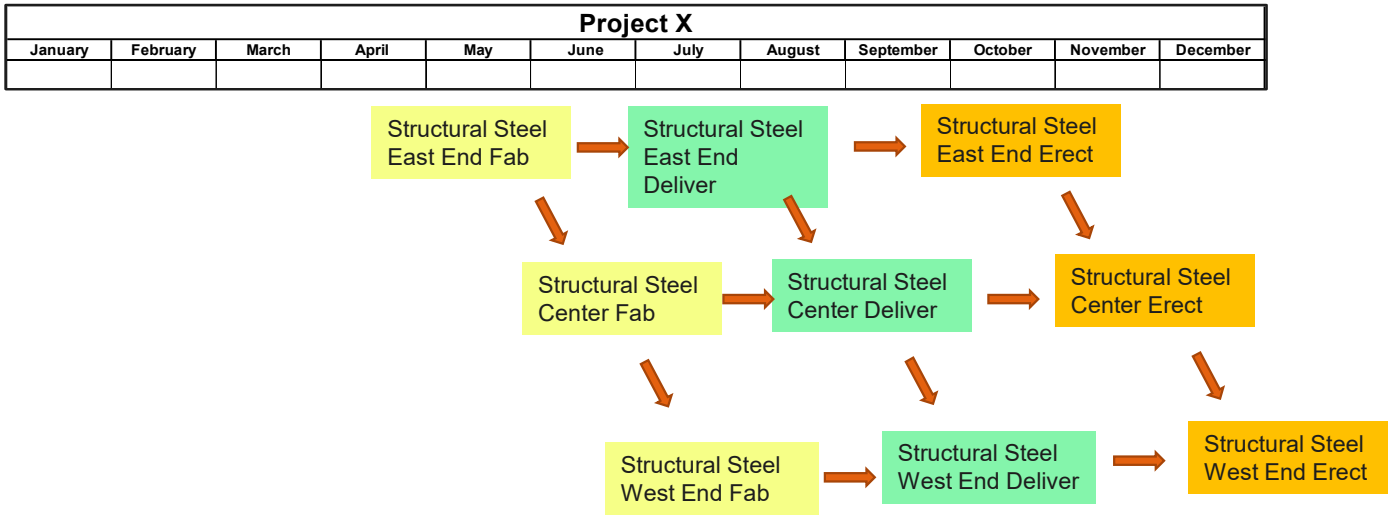

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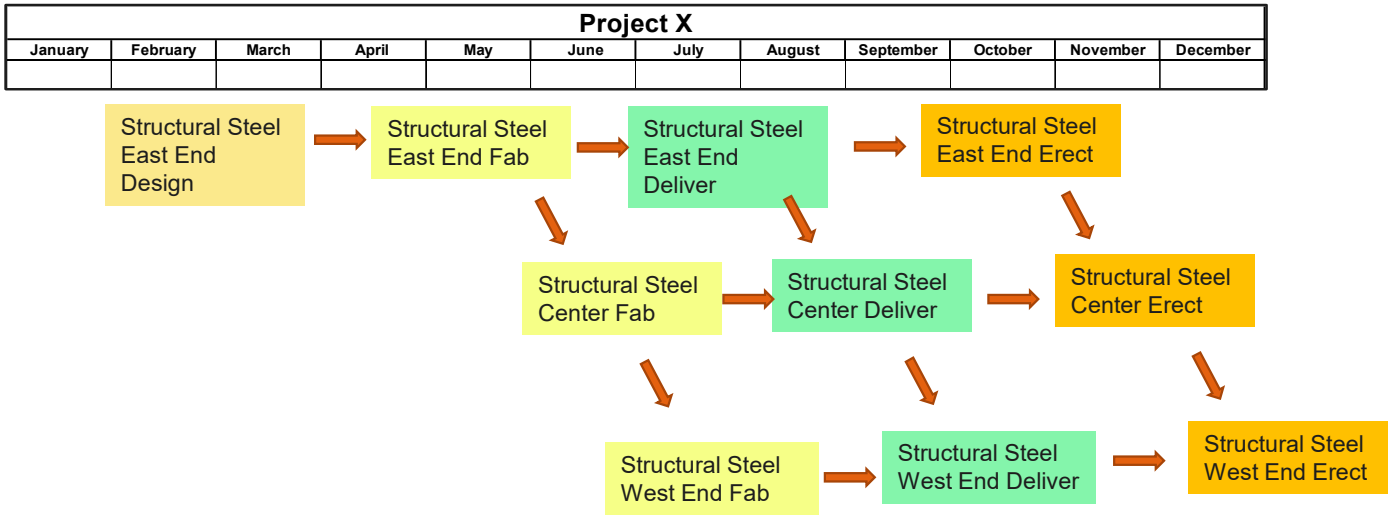

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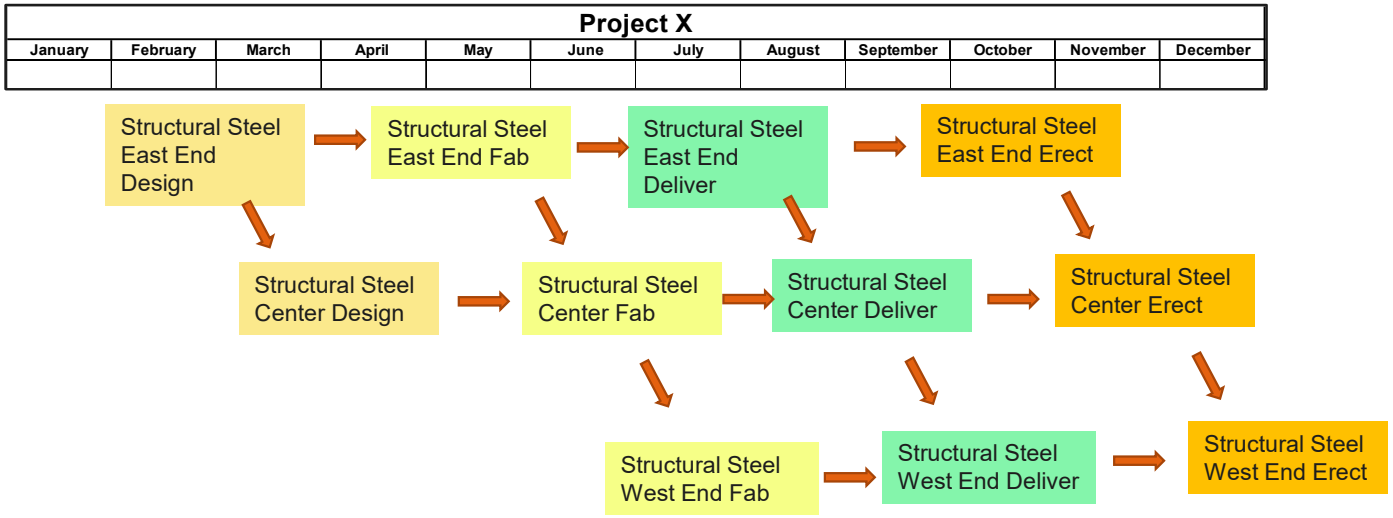

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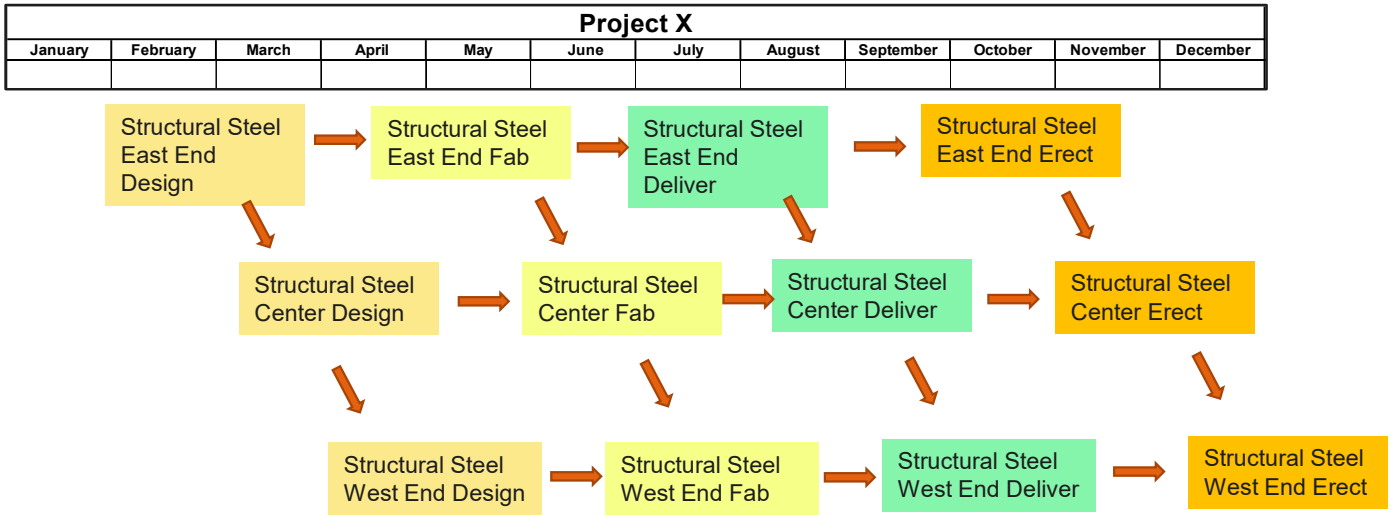

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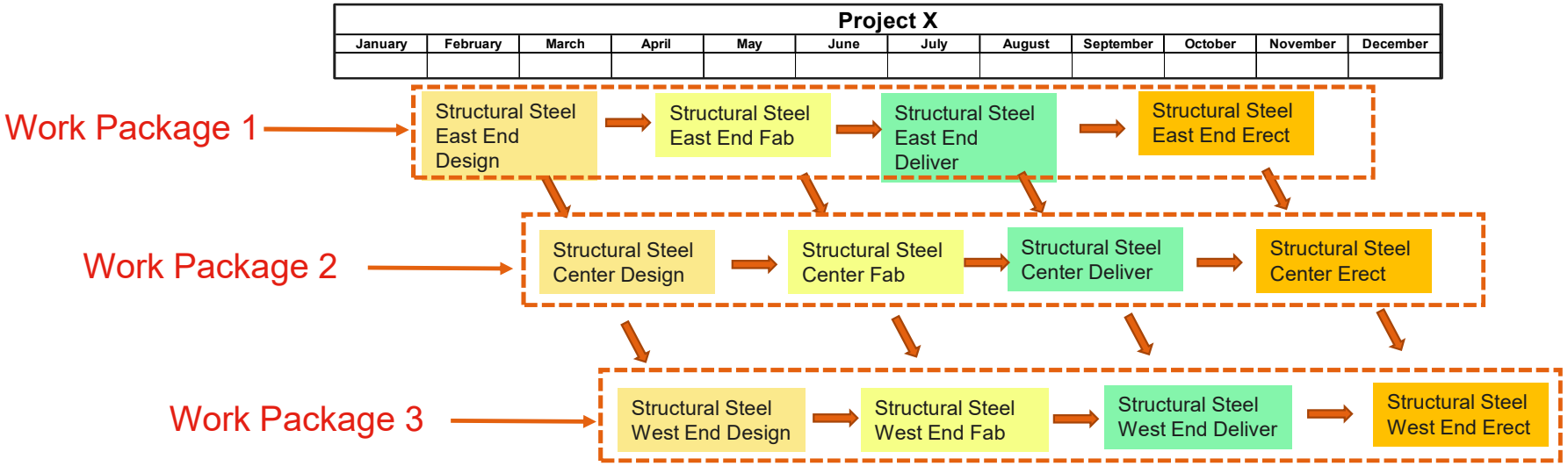

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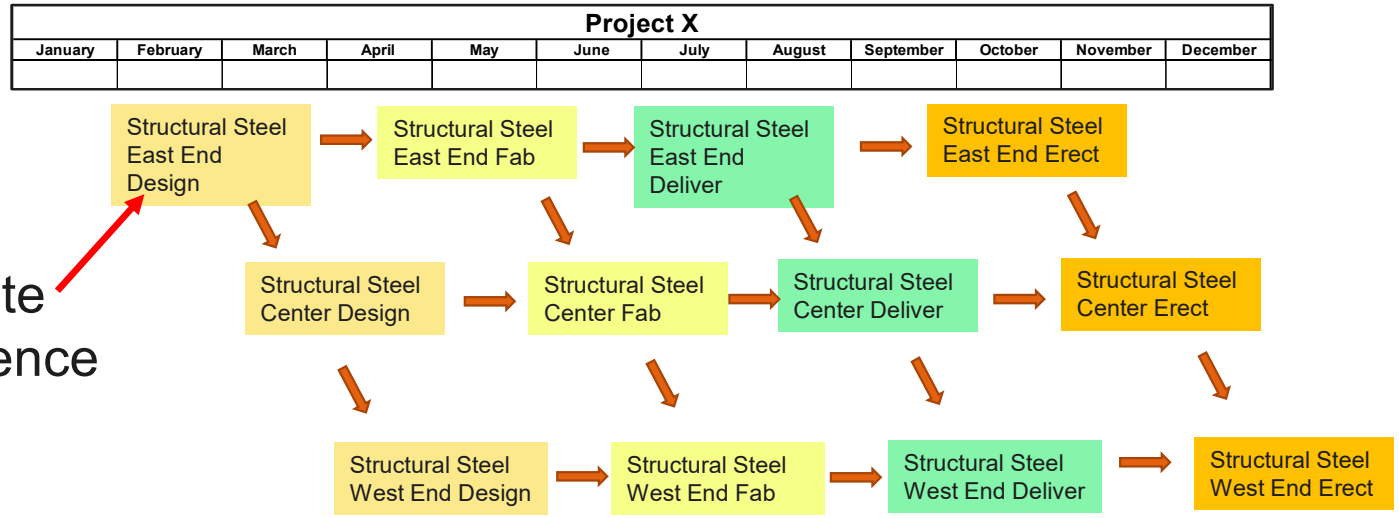

Required start date and design sequence location start

CPM Scheduling Maturity Needed

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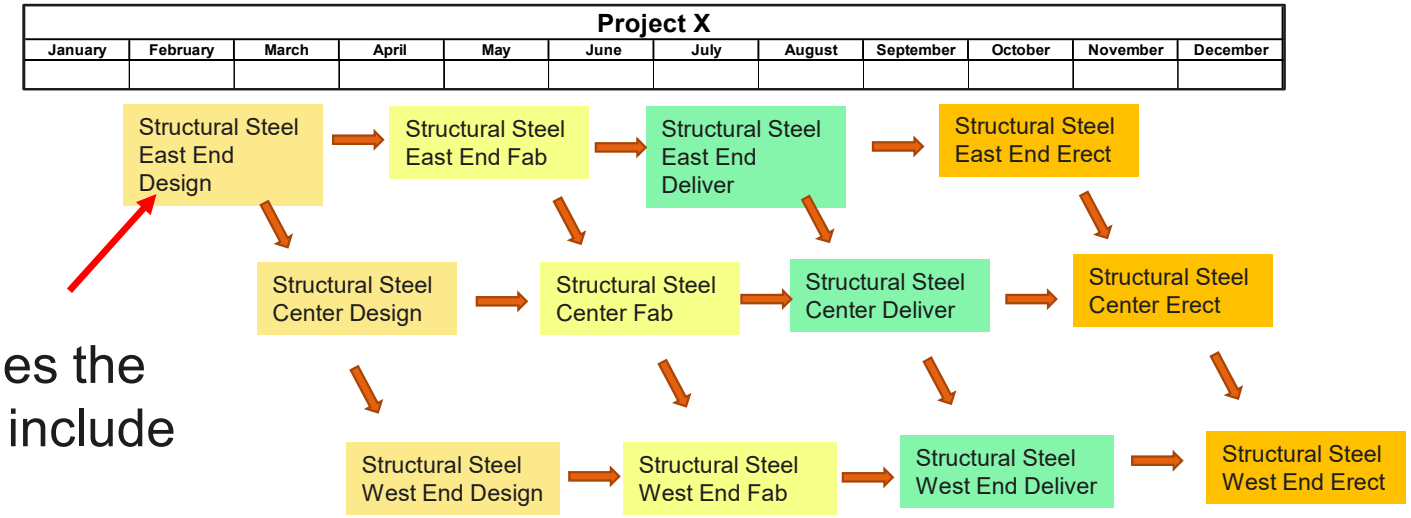
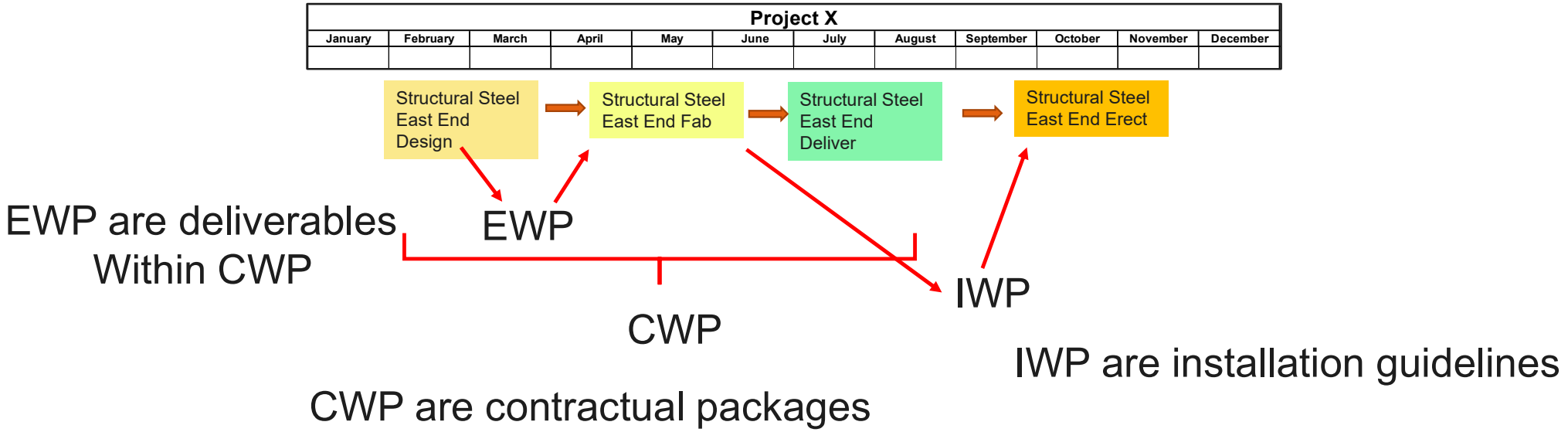


This establishes the CWPs, which include EWPs

Construction Work Packages (CWP)
Engineering Work Packages (EWP)
Installation Work Packages (IWP)

CPM Scheduling Maturity Needed

Work package intersections and dependencies



Construction Work Packages (CWP)
Engineering Work Packages (EWP)
Installation Work Packages (IWP)

Highly Collaborative Team Needed

CPM Schedule sequencing

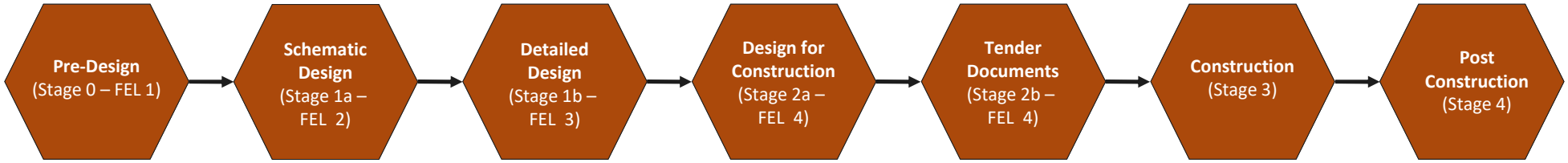
- This is early interactive planning
- Once the sequencing is complete, the engineering or architectural design is sequenced
- This allows early work packages to be released sequentially
  - Appropriate sequences

Integrated Stage-Gate Project Controls/Design

Integrated project controls/design in stage-gate approach – provides best support to meet goals

Integrated Stage-Gate Project Controls/Design

The most consistently successful results come from the Arcadis integrated Project Controls / Design Stage-Gate effort. This effort is aligned with 7 project lifecycle phases:



"Design-to-Budget"

Integrated Stage-Gate Project Controls/Design

The most consistently successful results come from the Arcadis integrated Project Controls / Design Stage-Gate effort. Each lifecycle phase is enhanced by Project Controls Services feedback in 4 areas: Cost, Schedule, Risk, Claims Avoidance

Pre-Design (Stage 0 – FEL 1) → Schematic Design (Stage 1a – FEL 2) → Detailed Design (Stage 1b – FEL 3) → Design for Construction (Stage 2a – FEL 4) → Tender Documents (Stage 2b – FEL 4) → Construction (Stage 3) → Post Construction (Stage 4)

Cost

1. Review statement of work/scope definition document
2. Anticipated maturity ~0% to 2% of final scope development
3. Develop screening estimate – Class 5 based on minimal scope definition
4. Factored estimate with range of accuracy ~ +100%/-60%
5. Establish conceptual budget
6. Identify major cost drivers for project type
7. Identify industry Constructability factors
8. Preliminary Value Planning - determine appropriate processes and materials
9. Plan for Stage-Gate estimates
10. Introduce concept of risk-based Cost Contingencies (unforeseen/uncertain)
11. Introduce concept of Cost Management Reserves (scope changes)

Schedule

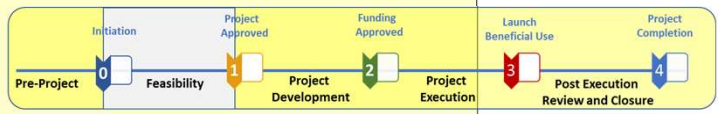
1. Choose Work Breakdown Structure (WBS)
2. **Identify Milestones, develop high level Class 5 Milestone Schedule - concept screening**
3. Identify scope of Master Schedule
4. **Determine Design scope/approach**
5. **Identify sequencing for work package planning**
6. Introduce concept of Time Contingency (unforeseen/uncertain)
7. Introduce concept of Schedule Management Reserves (scope changes)

Risk

1. Determine Owner Risk Tolerance
2. Preliminary plan for Risk Management
3. Develop conceptual Systemic Risk Assessment
4. Preliminary Go/No-Go decision for early sanction of project

Claims Avoidance

1. Recommend Project Controls practices from dispute lessons learned
2. Develop time management concepts for contracts
3. Develop claims avoidance, analysis, & dispute resolution concepts



Pre-Design

Integrated Stage-Gate Project Controls/Design

The most consistently successful results come from the Arcadis integrated Project Controls / Design Stage-Gate effort.

This effort is aligned with 7 project lifecycle phases:

Pre-Design (Stage 0 – FEL 1) → **Schematic Design** (Stage 1a – FEL 2) → **Detailed Design** (Stage 1b – FEL 3) → **Design for Construction** (Stage 2a – FEL 4) → **Tender Documents** (Stage 2b – FEL 4) → **Construction** (Stage 3) → **Post Construction** (Stage 4)

Cost

1. Review scope of work definition in drawings & basis of design
2. Anticipated maturity ~10% to 40% of final scope development
3. Develop budget authorization/sanction estimate – Class 3 based on drawings
4. **Factored/work package estimate – range of accuracy ~ +30%/-18%**
5. Authorize budget, sanction budget**, determine funding**
6. Monitor cost drivers
7. Perform project-specific Constructability Review
8. Provide Value Engineering
9. Second Stage-Gate estimate, ensure design is on budget
10. Develop risk-based Contingencies (unforeseen/uncertain)
11. Develop Management Reserves (scope changes)

Schedule

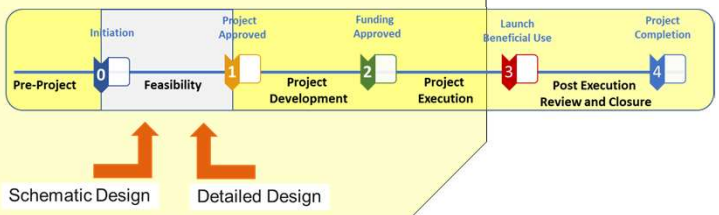
1. Develop full WBS
2. **Develop Class 3 Work Package Schedule for sanction**
3. **Confirm equipment, develop semi-detailed Class 3 Master Schedule**
4. **Develop, update, & monitor detailed Design Schedule**
5. Provide Schedule Constructability Review
6. Provide quantitative analysis for Time Contingency
7. Provide quantitative analysis for Time Management Reserves

Risk

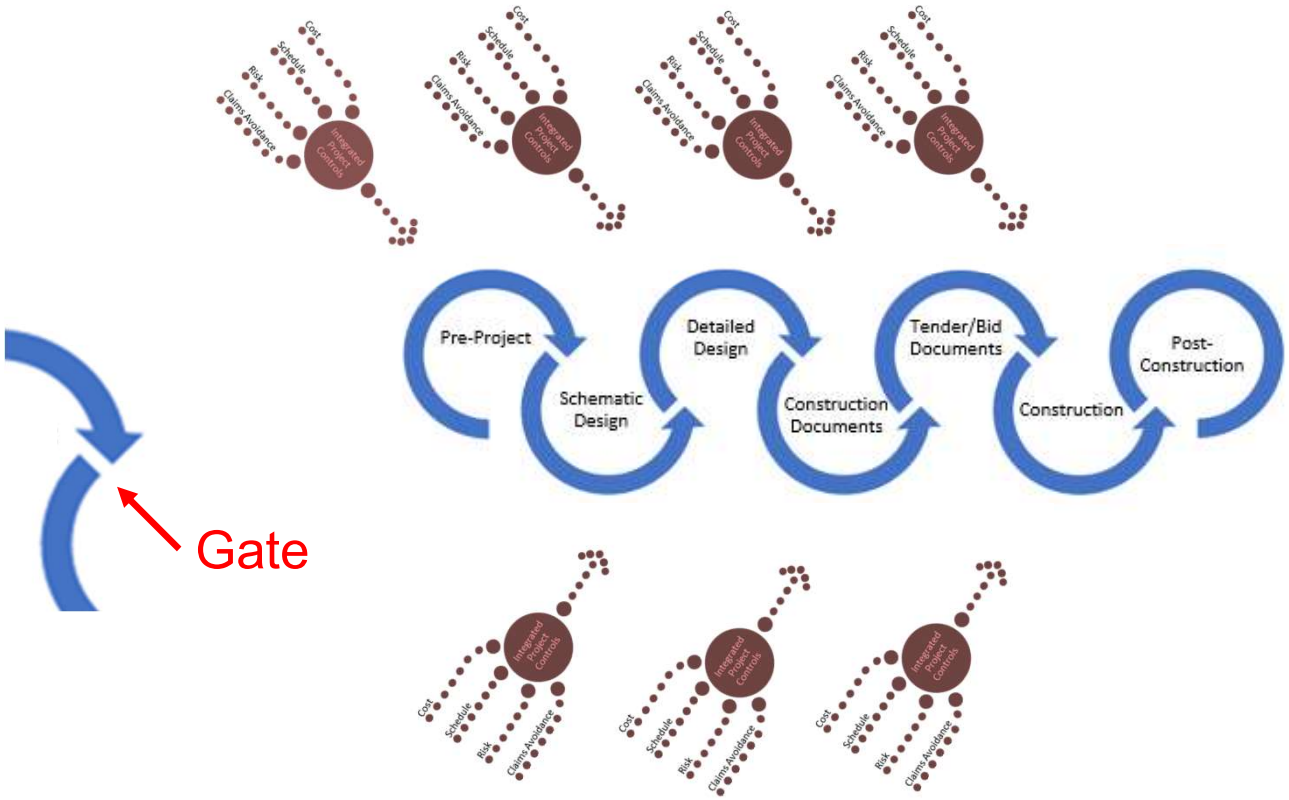
1. Re-evaluate adherence to Owner Risk Assignment needs
2. Facilitate Risk Workshop & Risk Register for project-specific risk
3. Implement Systemic Risk Responses
4. Finalize Go/No-Go decision for full funding

Claims Avoidance

1. Review specific Project Controls contract language
2. Review time management & changes language for contracts
3. Review claims avoidance, analysis, & dispute resolution language for contracts
4. Develop protocol for incentives/disincentives



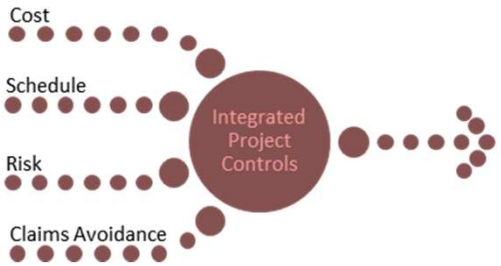
Integrated Stage-Gate Project Controls/Design



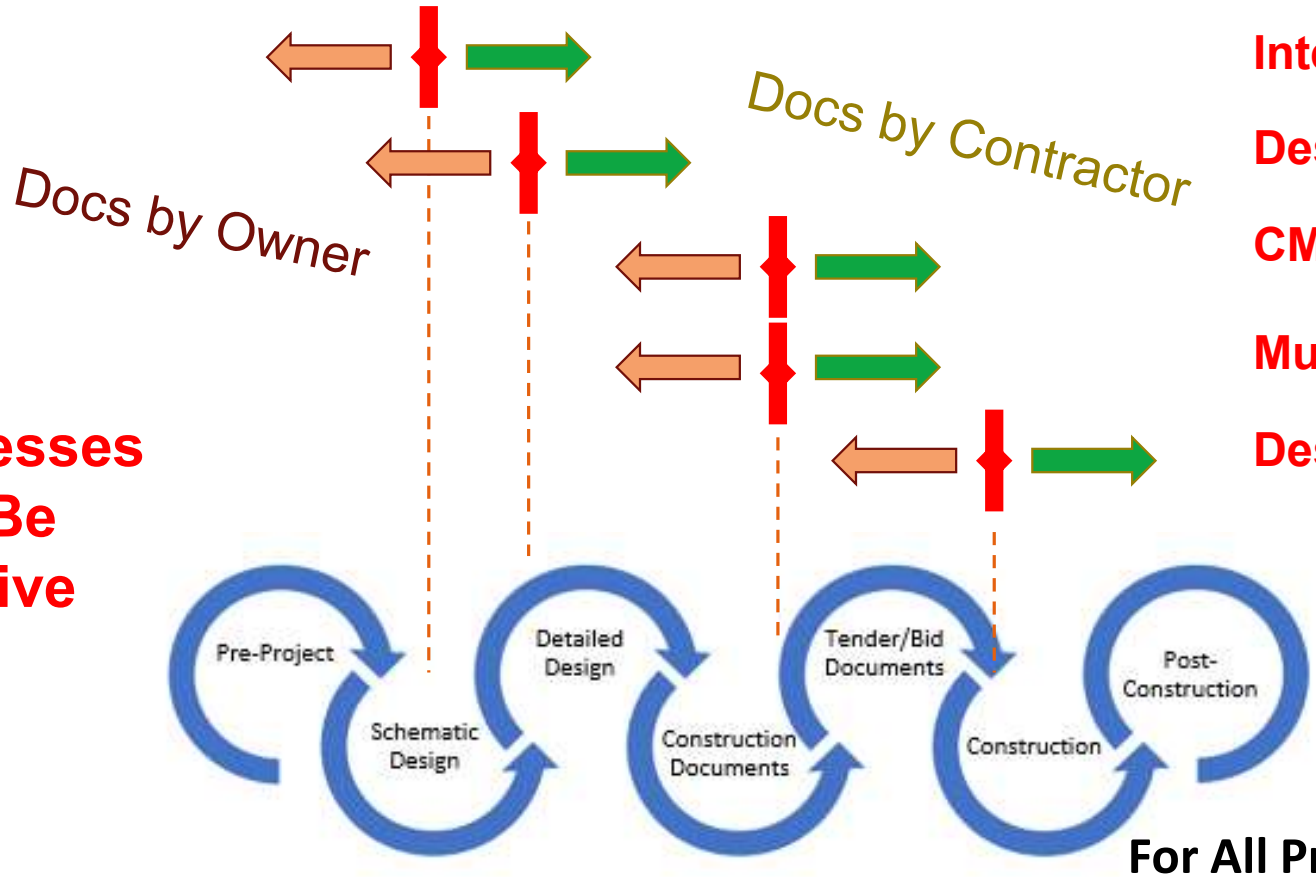
On Budget

"Design-to-Budget"

On-Schedule



Integrated Stage-Gate Project Controls/Design



Integrated Project Delivery

Design-Build/EPC/PPP

CM at Risk

Multi-Prime

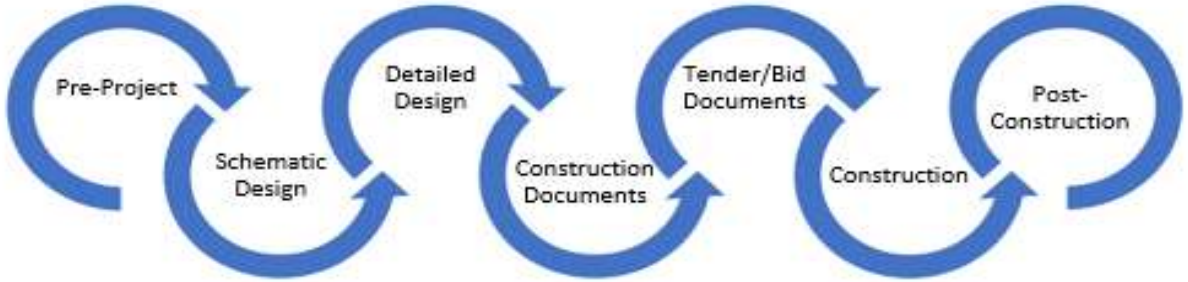
Design-Bid-Build

Processes May Be Iterative

For All Project Delivery Methods

Integrated Stage-Gate Project Controls/Design

The most consistently successful results come from the Arcadis integrated Project Controls / Design Stage-Gate effort. This effort is aligned with 7 project lifecycle phases:



Planning & Scheduling Services

Work Breakdown Structure	Select/Design	Develop CBS	Finalize WBS	Verify WBS	Document WBS	Monitor Scope	Reconcile Asset
Milestones	Identify	Verify	Monitor	Monitor	Set Contractual	Confirm	Audit Variances
Type of Construction Schedule	Class 5 Milestone	Class 4 - Feasibility	Class 3 - Detailed	Class 2 - Work Pkg.	Class 1 - Line Item	Review Contractor's	Move-In, Asset
Master Schedule	Identify Scope	Class 4 - Feasibility	Class 3 - Work Pkg.	Class 2 - Integrated	Class 1 - Work Pkg.	Update/Monitor	Analyze Variances
Major/Long Lead Equipment	Conceptual	Identify	Confirm	Monitor/Verify	Release Suppliers	Confirm	Audit Variances
Approach/MOT/Sequencing	Evaluate	Establish	Finalize Approach	Monitor/Verify			Lessons Learned
Work Packages	Plan CWP - Const.	ID Trade Packages	EWP - Engineering	EWP - Engineering	Develop IWP	Verify IWP - Install	Review Process
Design Schedule	Conceptual	Class 3 - Baseline	Update/Monitor	Update/Monitor	As-Built		Lessons Learned
Schedule Constructability	Plan	Preliminary	Review	Verify/Assess VE	Confirm VE Impacts	Review VE	Audit Variances
Schedule Optimization			ID Delay Drivers	Provide Optimized	Verify	Recommend	Analyze Claims
Options/Allowances			Evaluate	Identify Impact	Confirm Contract	Assess Variances	Audit Variances
Time Contingency		Evaluate Need	Qualitative	Establish Duration	Evaluate Options	Draw-down	Finalize Draw
Management Reserves		Evaluate Need	Qualitative	Recommendations	Finalize	Draw-down	Finalize Draw
Change Management		Benchmark Time	Verify Benchmark	Verify Benchmark	Coordinate w/ Risk	Review TIAs	Review TIAs

Highly Collaborative Team Needed

AWP needs highly collaborative design and construction

- Contract mandates collaborative iterative engagement of full team
- Understanding construction sequencing before design starts is vital

Works with all Project Delivery Methods

AWP needs highly collaborative design and construction

- The collaborative effort takes owner, designer, construction manager, contractor working together
- Project delivery methods require different approaches
  - DBB – Design-Bid-Build – rare for contractor involvement, common for CM Advisor
  - EPC – Engineering Procurement Construction – good approach
  - DB – Design Build – similar to EPC – good approach
  - P3 – Private Public Partnership – similar to EPC – possible approach
  - CMAR - CM at Risk – good approach – owner still hires designer
  - IPD - Integrated Project Delivery – probably best approach
  - Multi-Prime – requires strong coordination

Does the AACE TCM Framework Support AWP?

Issues with AWP Implementation

General Issues

- Advanced Work Packaging requires reasonable maturity in Planning & Critical Path Method Scheduling
- AWP needs highly collaborative design and construction

AACE Specific Issues

- TCM Framework does not explicitly discuss AWP
- TCM Framework does support work package sequencing

TCM Does Not Explicitly Show AWP

Section 4.1 Project Implementation

- Defines asset scope
- Communicates leadership team functional characteristics or design basis
- Establishes objectives and targets
- Establishes constraints and assumptions
- Communicates project implementation basis

- This section helps establish the goals for sequenced work packages
- Accommodates Advanced Work Packaging

TCM Does Not Explicitly Show AWP

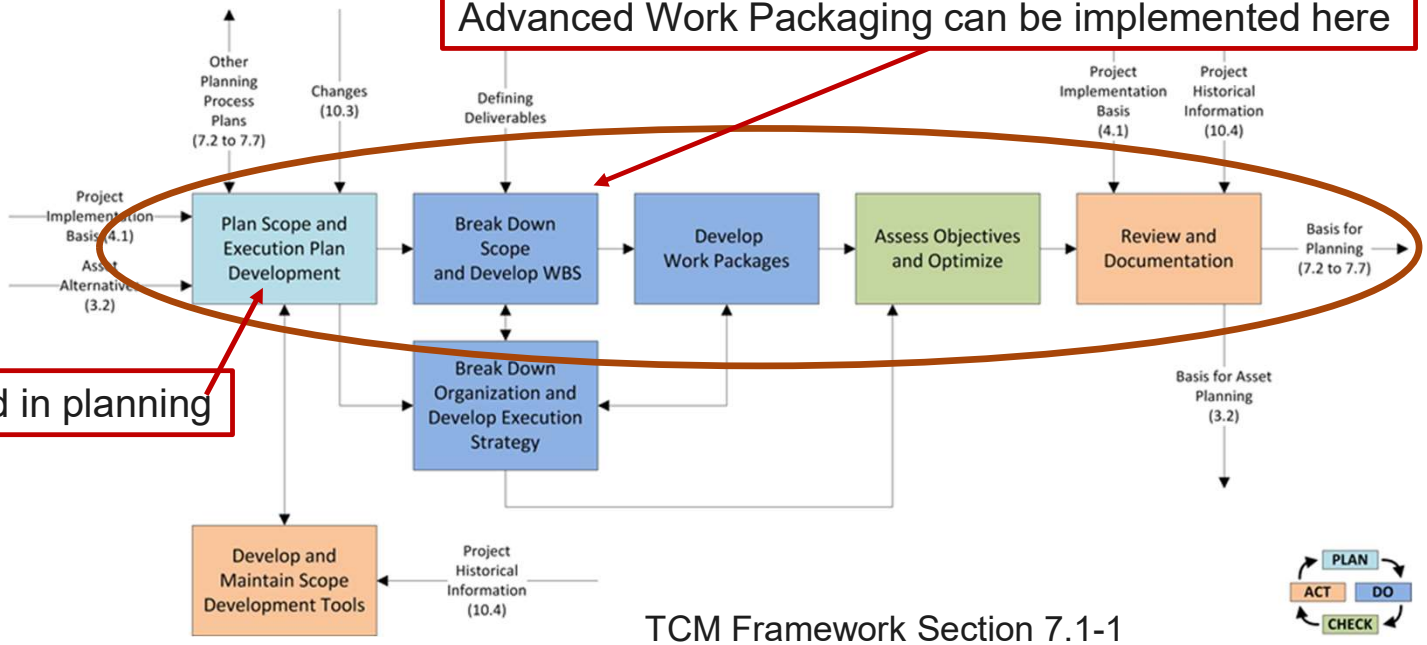
TCM Framework does not explicitly discuss AWP

- Section 7.1 Project Scope & Execution Strategy
- Section tends to emphasize iterative process more than sequencing
- Sequencing tends to be part of the planning discussion into execution strategies

TCM Does Not Explicitly Show AWP

How Does TCM Framework Relate?

Advanced Work Packaging can be implemented here



AWP is supported in planning

TCM Framework Section 7.1-1
Process Map for Project Scope & Execution Strategy Development
Used with permission from AACE International

TCM Does Not Explicitly Show AWP

Section 7.1.1 Plan Project Scope & Execution Strategy

- Define conceptual project scope
- Define conceptual project execution strategy
- Sets up Stage-Gate process for scope alignment
- Document and update

- This section helps establish the need for sequenced work packages
- Accommodates Advanced Work Packaging

TCM Does Not Explicitly Show AWP

Section 7.1.2 Break Down Scope & Develop WBS

- Translate ultimate deliverable into component deliverables
- Component deliverables include:
  - Sketches, diagrams, layout drawings
  - Equipment lists, specifications

- This section helps establish the plan for sequenced work packages
- Accommodates Advanced Work Packaging

TCM Does Not Explicitly Show AWP

Section 7.1.4 Develop Work Packages

- Plan component deliverables as work packages
- Work Packages are the integration of:
  - Organizational Breakdown Structure (OBS)
  - Work Breakdown Structure (WBS)

- This section helps define scope and responsibility for sequenced work packages
- Accommodates Advanced Work Packaging

TCM Supports AWP

While a culture of poor CPM scheduling makes it very hard to move into AWP,

Proper use of the TCM Framework And good CPM scheduling techniques

Do support and accommodate Advanced Work Packaging

Lessons Learned to Start on the Path to AWP

Lessons Learned

Requires early detailed planning

Performance depends on:

- A/E adoption and adherence to sequencing
- Careful design scheduling/monitoring is significant indicator of AWP success
- Scope creep derails AWP – need strong phase-gate project controls integration
  - Validate budget at stage-gates
  - Validate schedule at stage-gates
- Schedule is the driver for planning and execution
- Contract adoption of AWP

Lessons Learned

Failure Keys/Difficulties

- Resistance to change to AWP
- Lack of buy-in
- Lack of scope freeze
- Late design deliverables
- Poor controls process

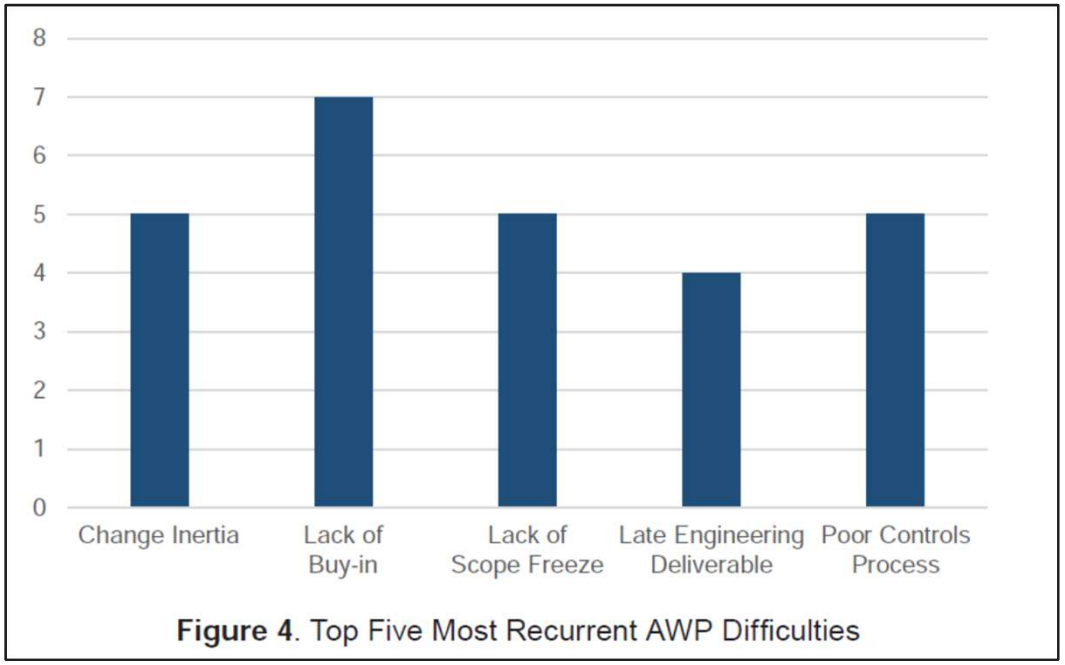


Figure 4. Top Five Most Recurrent AWP Difficulties

Lessons Learned

Major Benefits

- Better accountability of stakeholders
- Alignment across disciplines/trades
- Craft retention
- Information visibility
- Predictability

Why is AWP Valuable?

AWP Maturity Model

- Documented performance

Table 2. AWP Maturity Stages and Project Performance

	Maturity Stage		
Performance Dimension	**1. AWP Early Stage**	**2. AWP Effectiveness**	**3. AWP Business Transformation**
Productivity	Around 10% increase	Around 25% increase	Around 25% increase
Cost	Project on budget	TIC 10% below estimates	TIC 10% below estimates
Safety	Zero lost time incidents (TRIR below company average)	Zero lost time incidents (TRIR improves with sporadic first-aids and near misses.)	Zero lost time incidents (TRIR improves with sporadic first-aids and near misses.)
Predictability	Significant deviation from baseline estimates	Minor changes to execution schedule	Execution schedule to plan
Quality	Rework in line with previous quality performance	Rework slightly below company's average	Rework substantially below company average; substantial reduction of RFIs
Schedule	Project on schedule or experienced minor delay	Project slightly ahead of schedule during execution	Project slightly ahead of schedule during execution

From: "Making the Case for Advanced Work Packaging as a Standard (Best) Practice", by CII

IN SUMMARY

What to keep in mind…

The strongest step towards AWP implementation is good early CPM scheduling planning

Design sequencing and schedule are vital to success

Some of AWP that yields benefits requires formalizing contracts, procurement, installation plans, and schedule control

AWP is a worthwhile process to embrace and a natural evolution from good CPM scheduling

Conclusion

Collaboration is the Key!

Embrace good CPM Scheduling

Plan sequencing in detail

Contract for sequencing

Include AWP in contracts

Ensure CPM schedule has IWP implementation

Construction Work Packages (CWP)
Engineering Work Packages (EWP)
Installation Work Packages (IWP)

Construction Industry Institute (CII) Research Studies

Thank you!

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