هيئة كفاءة الإنفاق والمشروعات الحكومية
Expenditure Efficiency & Projects Authority

EXPRO National Manual for Projects Management

Volume 7, Chapter 4

Project Schedule Development Procedure

Document No. EPM-KPP-PR-000002 Rev 002

Document Revisions History:

Revision:	Date:	Reason For Issue
000	31/01/2018	For Use
001	07/01/2019	For Use
002	23/08/2021	For Use

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1.0 PURPOSE

To provide the project team, contractors and all stakeholders with adequate level project schedules, and sufficient information to establish baselines, monitor status and progress, analyze changes and impacts, provide big picture overviews, enable detailed schedule analysis, and enable timely schedule generation.

The purpose is to provide schedule development guidance starting with and including Stage Gate 3 of the Project Stage Gate Procedure EPM-EQ0-PR-000001. Pre Stage Gate 3 schedule development procedures are found in the Project Registration and the Concept Design & Planning volumes of the White Book.

This procedure applies to works performed under all Government construction projects executed throughout the Kingdom of Saudi Arabia.

2.0 SCOPE

The hierarchical construct of project schedules provides levels of schedule detail appropriate to the different needs of the project team.

- Level 1: Management Schedules (MS)
- Level 2: Summary Schedules (optional)
- Level 3: Control Schedules (CS)
- Level 4: Subject Matter Schedules (optional)
- Level 5: Detailed Trackers

3.0 DEFINITIONS

Definitions	Description
Contractor	Refers to the Prime Contractor, Supplier, Vendor, etc., who has a contract with the Entity of a project and has the full responsibility for its completion.
Critical Items Action Report (CIAR)	Listing of all project critical items that require management attention and resolution
Issued for Construction (IFC)	Engineering document that is ready to be constructed
Issued for Fabrication (IFF)	Engineering document that is ready to be fabricated (normally after vendor prints approval)
Level 1: Management Schedules (MS)	A 1 page (normally A3 size) summary schedule including baseline, current forecast, risk items, critical path, and key events
Level 2: Summary Schedules	For large projects only, schedules addressing specific sites, markets or regions, as a refinement and supplement to the Level 1
Level 3: Control Schedules (CS)	Centre piece of the scheduling system, developed on CPM schedule software by the contractors, which captures all direct work (and critical indirect work) with a balanced level of detail
Level 4: Subject Matter Schedules	As required, specific scopes that demand more detailed analysis (complex installations, intricate coordination with others, …)

Level 5: Detailed Trackers	Lowest level of detail, working documents for respective departments, like Engineering deliverable trackers, procurement deliverable trackers, construction quantity tracking, Start-up tracking, …
Project	Project to be undertaken by an Entity that consists of single or multiple Agreements with 2nd Parties to perform Works or Services as part of the execution plan to deliver such Project. Scope of Work and/or services identified by Entity that needs to be executed
Project Team	Entity and Contractors

4.0 REFERENCES

1. EPM-KPP-PR-000001 - Project Planning and Scheduling Definitions and Concepts Procedure
2. EPM-KPP-PR-000007 - Project Schedule Look-ahead Procedure
3. EPM-KPC-PR-000005 - Project Engineering Tracking Procedure
4. EPM-KPC-PR-000006 - Project Quantity Tracking Procedure

5.0 RESPONSIBILITIES

Level 1 to Level 4 schedules are normally maintained by the project's project controls team.
Level 5 trackers are established and maintained by the departments, with project controls oversight and support.

5.1 Planning Responsibilities

The plan belongs to the manager, superintendent or supervisor in charge of the work, who are responsible for alignment to the overall project execution plan, means and methods, coordination with others, completeness of scope, and achievability of plan and timeline.

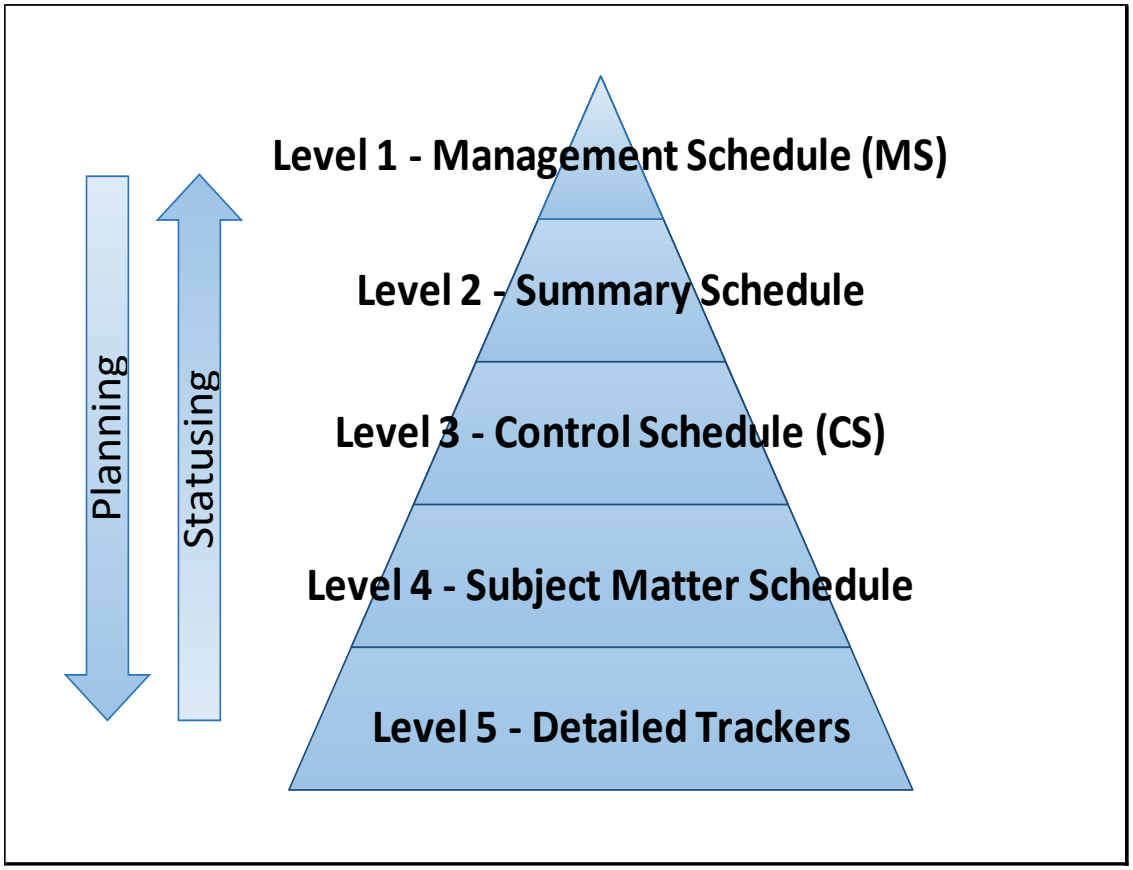
5.2 Scheduling Responsibilities

The planners/schedulers are responsible for compiling the information from the work owners, produce the schedules, ensure schedule integrity, and assess viability.

6.0 PROCESS

6.1 PROJECT SCHEDULE HIERARCHY

Below a graphical representation of the Schedule Hierarchy:



Planning should be done top-down, as the initial plans are conceptual and very high level, but with the expectation that they are to be met.

Statusing, on the other hand, is bottom-up, as the lower level trackers and schedules are used to update the higher level schedule activities.
Schedule levels are an indication of degree of detail of the schedule. Schedule levels are not an indication of schedule maturity.

Following chapters discuss the processes and procedures for each schedule level in the hierarchy.

6.2 LEVEL 1 - MANAGEMENT SCHEDULE (MS)

6.2.1 PURPOSE

A Level 1 Management Schedule (MS) is a summary schedule for project management that contains all project or contractor scope, reflects the execution plan, complies with contractual commitments, depicts critical path, and provides status against baseline.
The purpose of this schedule is to effectively communicate schedule status to high level management within Contractor, within Project, and to Entity.

6.2.2 SCOPE

The Level 1 is the highest level of project schedule and depicts the entire scope of the project or contract in a time-scaled graphic. The Level 1 integrates with Entity's strategic Master Plan of Projects. The master plan firstly sets out expectations of project timing and duration, and once a project is in execution, the project's Level 1 provides status to update the Entity Master plan.

The Level 1 Management Schedule has following key features:

- Agreed/Contractual milestones (with baseline milestones being contractual requirements, and current milestones being current forecast)
- Critical path, and analysis
- Identification of key Risks
- Schedule Contingency
- Narrative

The original baseline Milestone Schedule is developed based on the awarded contract. It shall not change unless agreed to by all parties through a scope change.

Against this baseline, actuals and forecast shall be shown. Normally this is fed from the Level 3 Control Schedule and is live. Forecasts do not establish new commitments. The commitment is always the baseline. If forecasts exceed baseline, explanation must be given and mitigations proposed.

6.2.3 PROCEDURE

The schedule package (the contractor's Planning & Scheduling deliverable requirements (procedure EPM-KPP-PR-000005)) includes project and activity durations, critical paths, risk analysis, contingency, resource distribution and all other relevant information.

The Level 1 Management Schedule, as part of this package, is developed during the bidding phase, and forms the basis of the project baseline at award.

6.2.4 Key aspects of a Level 1 Milestone Schedule

Software: Spreadsheets are best suited for Level 1 Management Schedule production as they allow adding textboxes with explanations, symbols and tables as required.

Layout: Activities in waterfall format, starting from upper left, towards lower right. Grouping as required to align with agreed Work Breakdown Structure (WBS).

Legibility: Even though common sense, oftentimes schedules are issued illegibly. That is ground for immediate rejection. It is suggested to use A3 format to improve legibility.

Revisions: Good revision control is required. Approved Baseline shall be Rev.0.

Total Scope: All major aspects of the scope need to be represented, including key indirect works like mobilization and/or construction of temporary facilities.

Activity Durations: Baseline durations are initially based on historical data, or calculated from man-hours and unit rates for given quantities and assumed resource availability, or based on contractual requirements.
Forecast durations are most likely durations based on current status, current and expected resources, current performance and current execution strategy.

Milestones: All contract defined start, intermediate and finish milestones are to be included in Level 1 schedule. The Level 1 is to display both baseline and forecast dates.

Major enabling works: For example, access roads, excavation and backfill activities, and critical underground activities.

Major Equipment Activities: For example, design, delivery and installation of baggage handling equipment, HVAC, and electrical substations.

Major Bulk Commodity Activities: For example, design, delivery and installation of structural steel, and High Voltage Cable.

Major Interfaces: Major interfaces with Entity, other Contractors, and others should be shown.

Pre-commissioning and commissioning activities: Pre-commissioning and commissioning includes electrical energizations, key system testing, and major component testing.

Abnormal Work periods: Identify Abnormal Work Periods with “curtain” periods of impacted productivity, for example, peak summer, National Holidays, Ramadan, etc.

6.3 LEVEL 2 – SUMMARY SCHEDULE

6.3.1 PURPOSE

For large projects, a Level 2 Summary Schedule might become necessary to adequately summarize a project timeline for senior management that contains all project or contractor scope, reflects the execution plan, complies with contractual commitments, depicts critical path, and provides status.

As with Level 1, the purpose of this schedule is to effectively communicate schedule status to high level management within contractor, and from contractor to Entity.

Additionally, Level 2 is to explicitly show all timings for all disciplines in all areas and can serve as basis for initial resource loading exercises.

If an initial Level 2 is developed, it then will serve as the basis for Level 3 schedule development.

Level 2 schedules are normally several A3 sheets in size.

6.3.2 SCOPE

The Level 2 is a high level project schedule. It depicts the entire scope of the project or contract in a time-scaled graphic. It integrates with Entity's strategic Master Plan of Projects.

6.3.3 PROCEDURE

The schedule package (the contractor's Planning & Scheduling deliverable requirements (procedure EPM-KPP-PR-000005)) includes project and activity durations, critical paths, risk analysis, contingency, resource distribution and all other relevant information.

The Level 1 Management Schedule, as part of this package, is developed during the bidding phase, and forms the basis of the project baseline at award.

- If critical to project, it may introduce work breakdowns within areas and disciplines, in fact may introduce the concept of work packages.
- Expands on definition and visibility of key relationships
- Apart from spreadsheet software, other simple scheduling software might be used. Integrated resource loading capability would be beneficial.

6.4 LEVEL 3 – CONTROL SCHEDULE (CS)

6.4.1 PURPOSE

The Control Schedule (CS) is a comprehensive project schedule containing the Contractor's scope of work at a level of detail that provides management with an optimum plan for the work, and project supervision with a roadmap for implementing the schedule. The CS includes sufficient information on priorities, progress, potential problems, changes, impacts, and recovery planning to enable the project team to manage and control the work.

6.4.2 SCOPE

The CS contains all the work Contractors are contractually responsible for performing, managing, monitoring, or reporting. Additionally activities, restraints or constraints by others that affect Contractor's work schedules (e.g. Entity procurement of permits, regulatory approvals, work by other entities coordinated directly by Entity, Entity Operations).

The CS, Level 3, verifies the Management Schedule (MS), Level 1, with a bias toward completing work prior to it, and provides work volume and priority requirements to lower level schedules, such as Subject, Medium Term and Summary schedules and the Engineering, Procurement, Construction, and Pre-Operation Testing and Commissioning Schedules Trackers (Level 5). The CS comprises the entire project scope, including the integration of the engineering, procurement, construction, and startup phases of the job, and includes all significant, Project and non-Project, events required to perform the work. It monitors current status, forecasts progress, and is used as the control tool to analyze and manage downstream impacts, make pro-active decisions, and deliver the project in accordance with the contract schedule. The critical path method (CPM) is used for the CS (except for some linear and mass logistic projects that use March Charts). The CS contains between 1,000 to 5,000 activities resource loaded with manual man-hours and bulk quantities design release and construction installation. The control schedule shall be created and maintained in some form of CPM planning and scheduling software package.

The CS includes all significant events (e.g., key deliverables, contractual milestones, critical interfaces, etc.) that must be integrated during performance of the engineering, procurement, construction, and Pre-Operational Testing phases of the job. The contract and the current budget are the absolute measures of scope of work by which project controls verifies that the scope of supply, services, and quantities in the CS is complete. Revisions and updates to the CS are managed under version control described in section 6.4.3.2.15. Key elements of the CS are:

- Project execution plan logic, reviewed by the project team
- Activity logic (relationships) and durations, reviewed and approved by the supervisor responsible for the work

6.4.3 PROCEDURE

6.4.3.1 Introduction

The Level 3 Control Schedule development procedure is structured as follows:

- Schedule development
- Baselining
- Schedule maintenance

6.4.3.2 Schedule Development

6.4.3.2.1 Introduction

The CS verifies in detail the MS plan, and provides the project team with a roadmap for achieving the schedule and a means for monitoring and managing it. As noted above, the CS does not determine the project completion date or other key schedule features but it does validate or confirm that what is in the MS can be

achieved. The CS provides direction to the lower level schedules which in turn provide status and verification back to the CS. The CS is the management tool for monitoring activity progress and status, identifying schedule problems and impacts, developing workarounds and recovery plans, and resolving schedule-related issues. The number of activities in the CS is kept to an appropriate count to fulfill its purpose within the schedule hierarchy.

Contractor, working with the project team and using the MS, Basis of Schedule, contract schedule, execution plan, cost budget and other sources, creates an optimum plan of work with a network analysis of logical sequences of work activities. The greatest benefit of CPM is the use of network analysis by the iterative development of fragnets to arrive at innovative and competitive project plans and schedules. Software is used to plot the logic, schedule, develop resource profiles, and production rate reports necessary for project controls and the project team to verify and deploy the schedule to manage the project.

The supervisor responsible for doing the work owns the plan and is responsible for the means and methods employed in the plan and the achievability of the schedule. The Project Team owns the schedule, the Lead Planner is responsible for compiling the plan and schedule and for its technical integrity and viability in terms of the logic, logistics, etc.

6.4.3.2.2 Schedule Basis

The CS is developed and maintained within the requirements outlined by:

- The Contract and the Proposal Schedule Package, which establish the overall phasing, critical area logic, key resource profiles, schedule curves, historical comparisons, and the backup and rationale for all key aspects of the schedule, including areas of risk and the measures incorporated to treat them and schedule probability analysis and contingency development
- The project execution plan, which outlines the means and methods for performing the work including any associated analyses (e.g. Constructability assessments)
- Project detail scope definition as developed by project engineering performed to date
- The project Procurement Tracker
- The project Delivery Tracker
- Current budget and current forecast man-hours and quantities
- Partner and joint venture input
- Permits/Government/Environmental approvals and sustainable development strategy
- Contracting and project execution strategy which encompasses such items as fabrication and modularization, camps and temporary facilities plans

6.4.3.2.3 Applicability

For most projects, Contractor will prepare a CS whether performing the job directly, or subcontractor service(s) for some or all of the scope of work. This procedure is generally written as if Contractor is responsible for performing the work directly; however, it applies to both cases. The major difference between the two cases is that in a direct control EPC job the Level 5 Trackers are produced by Contractor, whereas for a managed job, certain Trackers are prepared by subcontractors.

CSs for management projects may require a greater level of detail than for direct EPC jobs because additional interfaces between responsible parties. This includes elements such as:

- Interfaces between Subcontractors and Contractor
- Interfaces between Subcontractors
- Interfaces between Subcontractors and the Project, if applicable

When Contractor is performing the job in a partnership, the JV contract will typically state the division of scheduling responsibilities. This is normally not visible to an Entity, and a JV will have to provide a single point of contact for all planning and scheduling interfacing.

6.4.3.2.4 Schedule Structure

The schedule structure includes activity codes that divide the project scope into manageable units and provide clear delineation of interfaces, for organizing and assigning attributes to schedule activities, and resource definitions to identify the people and key equipment available for project execution.

6.4.3.2.4.1 Activity Codes

Organization of CS activities is performed via use of activity codes (not WBS code). These include codes for Function, Discipline, and Owner to assign responsibility for activities. Expro will define standard activity code structures for “common” project types.
Typical organizational formats for the EPC schedule phases include, but are not limited to:

- Engineering: By Area/Facility (and/or elevation on large projects)/ Category of Work and Discipline
- Procurement: By Purchase Order
- Contracts: By Contracts and Subcontracts
- Construction: By Area/Facility/ (and/or elevation on large projects)/Category of Work
- Commissioning/Turnover: By Commissioning System and/or Facility/Area Turnover

6.4.3.2.4.2 Project Work Breakdown Structure versus Schedule WBS code

The use of a data and reporting hierarchy is required on all projects. It is up to project controls to decide if a formal WBS should be prepared to assist in defining and organizing the work. This is considered a good practice and is in some instances mandated by contract. If the project employs a WBS, then each WBS level is assigned a schedule activity code in order to allow the maximum number of organizational permutations.

One of the major purposes of the WBS is to ensure that all scope/deliverables required to complete a project is accounted for in both the schedule and cost. All projects should utilize a WBS through an activity code structure which will typically include codes for the levels that make up a WBS, e.g., facility, area, work package, etc. and is more flexible than the scheduling software WBS, in that the schedule can be organized by any order of the codes.

6.4.3.2.4.3 Resource Definition

Resource definition identifies the resources (bulk commodities, type and number of craft and key equipment) that will execute the project and will be assigned to individual schedule activities as either resource or activity owners. This information is available in the form of bulk quantity track, the site manual labor staffing plans, and the construction equipment schedule.

6.4.3.2.5 Activity Definition

Activities are defined based on the total project scope and organization structure. General rules for CS level of detail are:

- Typically, 1,000 to 5,000 activities per project are required for the project team to manage and control the job. Mega-projects or programs of work that comprise a number of discrete sites, units, or sub-projects may have multiple CSs that are summarized in an overall Program Management Schedule.
- The detail required for execution of the work is included in the Level 5 Trackers. CS activities relate on a one-to-many basis to the line items/deliverables in the Trackers.
- The CS generally contains activity detail sufficient to depict integration of the engineering, procurement, construction, and startup phases, but not necessarily the flow of detail information that make up inter-discipline and cross-functional interfaces within a phase. The CS activities provide timeframes within which the detailed interfaces will occur.

6.4.3.2.5.1 Engineering

Engineering activities are typically created for the following:

- Work Package – Grouping of deliverables by area, system, or subcontract scope which can be identified as a single schedule activity per work package. The engineering work package starts with the first design activity and finishes with the last deliverable issuance.
- Material Requisition (MR) – Single activity for development of each significant MR. The MR is owned by engineering and identifies the material or equipment to be purchased by the project. The MR is used to describe the scope of work, required documents, and data submittals, and quality aspects for material to be purchased on a project. Where possible, each MR should be limited to one category of material or equipment that can typically be supplied by a single supplier. The MR is used as the basis to form the purchase order (PO) which is normally represented in the CS using a single bid, evaluate, award activity. Engineering and procurement must coordinate with project controls to obtain and understand the required-on-site date as well as estimated budget for material and equipment. Groups of minor MRs with similar required completion dates may be summarized into a single activity.
- Subcontract Bid Package Development – Activities may be added to the CS to cover key engineering tasks that are distinct from work package completion and are required to complete the Bid Evaluate Award process. With input from Engineering, the Lead Planner establishes a generic subcontract award schedule, this schedule outlines the generic durations and planning assumptions from initiation through award. The subcontract award schedule provides detailed plans for each subcontract and forms the basis of the contracts department tracking tool, the subcontract formation status report.
- Site Wide Design Documents – Selected key items, such as design criteria, general specifications, general arrangement drawings, Piping & Instrumentation Diagrams (P&IDs), and single-line diagrams, which are required for multiple work packages, may be incorporated into the CS at the individual activity level to enhance visibility and enable accurate analysis of engineering progress. Alternately, in the Engineering Tracker, general design document activities are mapped to a corresponding work package and are not carried individually in the CS.
- Area Specific Design Documents – Area specific and high volume documents should be added at the same level of detail as reported in the Engineering Tracker Control logs.
- The CS must include all task logs, for off project review, audit, supervision, co-ordination and training
- The CS should also include activities, such as client review, regulatory submissions, and interfaces required for good operation of the schedule.

6.4.3.2.5.2 Procurement

Procurement activities are typically created for the following:

- Bid, Evaluate, Award (BEA) – Single activity for purchase order bid, evaluate, and award. Activity starts with the issuance of a bid package and ends with award. Groups of minor purchase orders (POs) with similar required award dates may be summarized into a single activity.
- Vendor Data Submittals – Single activity for development and submittal of the first significant vendor data, e.g., required by Engineering to complete civil work package. Activity starts with award and ends with receipt. Subsequent submittals are identified by milestones as necessary.
- Fabricate and Deliver – Single activity for material or equipment fabrication and first delivery to the jobsite. Subsequent deliveries are identified by milestones as necessary.

6.4.3.2.5.3 Subcontracts

Subcontract activities are typically created for the following:

- Bid Package Development – Single activity for all tasks associated with bid package development.
- BEA – Single activity for subcontract bid, evaluate, and award. Activity starts with the issuance of a bid package and ends with award.
- Subcontractor Data Submittals - Single activity for development and submittal of first significant data. Subsequent submittals are identified by milestones as necessary.
- Mobilization – For installation subcontractors, single activity or milestone for mobilization to the jobsite.
- Material Deliveries and Construction – Fabrication/delivery and construction activities are included the same as described in Sections 6.4.3.2.5.2 and 6.4.3.2.6.

6.4.3.2.6 Construction

Construction activities restrained by Engineering, Procurement, and Subcontract deliverables must be defined at a level of detail such that management of interfaces make viable accountability and enable accurate analysis of construction progress and performance. Analysis includes visibility of downstream impacts on pre-operational testing and commissioning, as well as key project milestones. Construction activities are typically created for the following:

- Work Package – Typically one activity per package or group of packages. More activities may be added for packages of greater scope, interdependencies, and/or to reflect logic.
- System/Area Completion Tasks – Activities include system/area punchlist generation walkdown, completion of punchlist items, and milestones for turnover to Commissioning Team or Entity.

6.4.3.2.6.1 Pre-Operational Testing, Commissioning and Turnover

The Pre-Operational Testing, Commissioning and Turnover schedule comprises:

- Original Baseline CS Schedule – One activity per Startup system or area/room/facility. If commissioning systems have not yet been defined, then one activity is allocated per Engineering system. During the construction phase, the system commissioning schedule may be expanded to a higher level of detail (generally not more than five activities per system) in order to clearly define significant interfaces between subcontractors, intermediate steps in system commissioning, or interface with other systems. Any additional detail is managed via the commissioning system tracking schedules.
- Summary Level Activities – Used for non-system specific pre-commissioning, pre-operational testing, and final commissioning activities as contractually appropriate.
- Project Completion Milestone(s) – Identified as defined by the contract.
- Schedule contingency is included as an activity in the final pre-commissioning, pre-operational testing, or commissioning activities that lead to the contractual project completion milestone.
- Turnover activities in the level of detail agreed with the owner.

6.4.3.2.7 Logic and Phasing

CS logic is the representation of EPC sequences and restraints. In order to create an accurate model of the project, the logic for each phase shall display the appropriate integration points of each succeeding phase.

Schedule phasing is generally backward driven, with the completion requirements set by Pre-Operational Testing, Commissioning and Turnover driving Construction, then Procurement and finally Engineering deliverable dates. In more detailed terms, system turnover dates drive Construction phasing, and the beginning portions of the Construction schedule establishes the need dates for design information, procurement deliveries, and subcontract awards. Early dates for key material deliveries drive portions of construction. The EPC schedule is optimized for these deliverables.

The development of the Engineering Tracker and Procurement Tracker and the CS is an iterative process, with the CS providing priorities and construction need dates, and the Engineering Tracker and Procurement Tracker providing activity definition and completion date information. The completion dates provided by Engineering Tracker and Procurement Tracker to the CS will inevitably include some degree of preferential logic as a result of optimization of resource usage in the Level 5 Trackers.

6.4.3.2.8 Resource Levelling

Resource-levelling algorithms to optimize schedule in the CS produce variable results and therefore are not a requirement. Adding minimal preferential logic to the CS to level resources allows effective schedule smoothing. This process is described in Section 6.4.3.2.7.

6.4.3.2.8.1 Preferential Logic

In many instances, the CS is initially developed and a record file saved with only essential logic. Preferential logic is added, as necessary, to phase the work. Project Controls, working with the project team, must be able

to identify where preferential logic is included in the schedule, as it will be modified during schedule development iterations and after baseline development, as part of recovery planning. The purpose of preferential logic in the CS is to create an aggressive, but achievable, economically viable schedule that is resource leveled to achieve completion and is reasonably ahead of the MS schedule requirement for progress achievement. In achieving this purpose, the correct application of preferential logic:

- Optimizes float between the phases
- Minimizes creation of near-critical paths
- Levels resources to avoid unreasonable peaks and/or valleys in resource requirements

Addition of preferential logic is an iterative process that results in Construction's support of Pre-Operational Testing and Commissioning requirements for system/facility turnover, and Engineering / Procurement / Subcontract support of Construction with work package issuance, material deliveries, and PO/subcontract awards.

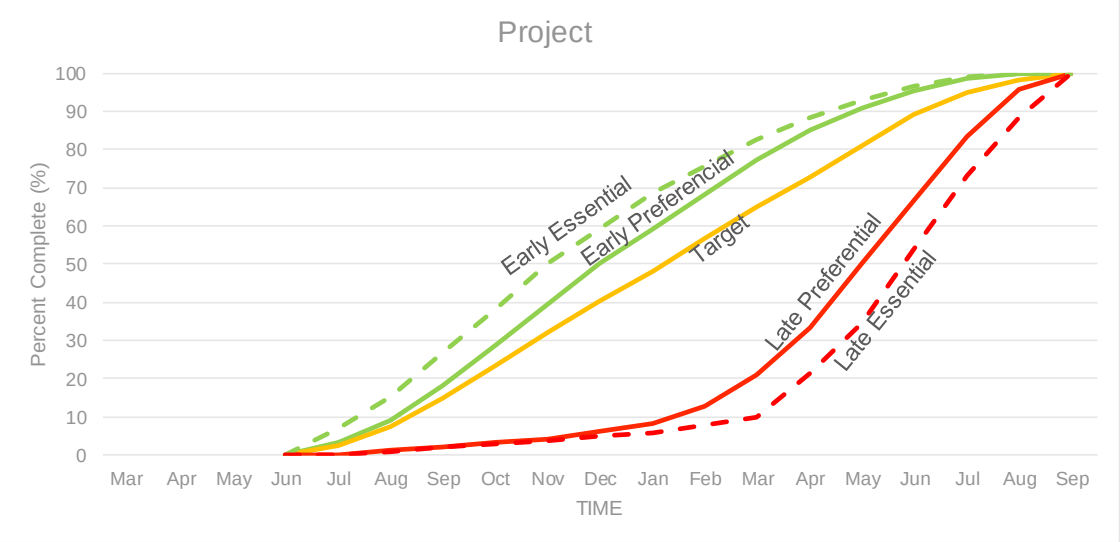


FIGURE 1 – Project's Progress Curve

Ideally, the scheduled resource curves generated by the MS will lie at a maximum of about a third of the way between the CS early-start and late-start curves. In an essential logic early-start schedule, engineering, procurement, and construction are compressed to such a degree that resource curves are front loaded and the curve will lie too far to the left (earlier than) the MS curves. Preferential logic is added to the CS to move the early-start schedule to the right (later) until an aggressively, taut schedule exists. The Lead Planner needs to agree with the Project Manager on any changes to project work off curves produced from MS as a result of the finalization of the CS, shown above as the Project Optimum curve, and to understand, communicate and manage the extent to which those curves represents an aggressive target. See **Figure 1**, above, for examples of curves depicting essential and preferential logic curves.

6.4.3.2.8.2 Constraints

Constraints are only used to model conditions that cannot otherwise be represented with normal predecessor/successor logic, and should be kept to a minimum. Best practices for constraints include:

- Not using constraints that will override schedule predecessor/successor logic
- Not using constraints that result in creation of multiple critical paths or distort the critical path
- Applying constraints to milestones/flags, not activities. This may require the addition of milestones/flags in order to depict constraints.

6.4.3.2.8.3 Engineering Logic & Phasing

Engineering activity logic flows shall include tasks and deliverables essential to engineering workflow and integration with construction, procurement and contracts. The integration points can be work packages, MRs, and bid package support deliverables.

The Engineering process requires substantial interchange of information between the disciplines (plant design, stress analysis, electrical, etc.) that is too detailed to depict in the CS logic. The level of detail in the information exchange is managed internally by Engineering with specific control point schedule evolution reflected in the Engineering Tracker.

If computer modeling is used for design engineering, then the logic of 30%, 60% 90% model reviews will need to be incorporated into the CS.

Standard engineering fragnets or logic diagrams for job types are to be developed and used. Necessary adjustments to pre-existing design logic are reviewed for inclusion by the project team to reflect specific project conditions. Standard engineering fragnets need engineering management review and approval.

6.4.3.2.8.4 Procurement and Contract Formation Logic & Phasing

Procurement and contract formation activity logic flows shall include activities and tasks essential to procurement and contract workflow and integration with construction. Material deliveries and contract awards are the major interface points for the procurement and contract schedule with construction. Deliveries tie to the first construction activities when material will be used. Contract awards tie to the initial design, fabrication, mobilization and/or construction activities that are dependent on the contract award.

Procurement and contract formation processes involve substantial interchange of data with engineering, and other function groups (e.g., Construction, Project Controls) in the course of developing purchase orders and contracts that are too detailed to depict in the CS logic. The detail of the information exchange is managed by Procurement with control point schedule evolution reflected in the Procurement Tracker.

6.4.3.2.8.5 Construction Logic & Phasing

Construction activity logic flows shall include activities and tasks essential to construction workflow and integration with Pre-Operational Testing and Commissioning. The major integration points are startup system turnover and facility/area turnover.

The Construction portion of the CS determines the required engineering work package IFC dates, the material required-on-site (ROS) dates, and the subcontract award dates. Project Controls makes certain that the early-start dates that define these requirements reflect the earliest viable construction need in order to allow for early completion opportunities. This includes ensuring that:

- Work Package IFC need dates include durations for field engineering preparation of construction work packages.
- Material ROS dates allow sufficient time for inspection and material handling.
- Subcontract award dates allow sufficient time for subcontractor fabrication and mobilization prior to installation.

Bulk commodity installation is typically initiated on a facility/area/elevation basis. Completion requirements are typically on system/area turnover basis. In order to logically tie bulk commodities to system/area turnover, some critical commodities must be scheduled at a facility or area system level of detail and then linked to system completion activities. The remaining commodities are scheduled at a summary level and linked to a mechanical completion date based on the last startup system or required facility turnover date. Preferential logic is added to phase the construction schedule and account for factors such as resource availability (labor and equipment), crew densities, logistics (e.g., crane locations), site conditions, and multiple shift requirements.

6.4.3.2.8.6 Pre-Operational Testing, Commissioning and Turnover Logic & Phasing

Pre-Operational Testing, Commissioning and Turnover are the final phases flowing to project completion. All preceding phase logic must flow through the construction turnover to Pre-Operational Testing milestones. The required dates for construction turnover are defined such that Pre-Operational Testing, Commissioning and Turnover have sufficient time to complete their work at the required confidence level for timely project completion. All Pre-Operational Testing, Commissioning and Turnover logic must flow through to contractual project completion milestones.

6.4.3.2.9 Activity Duration Estimate

The Original Baseline CS critical path duration is the same as developed in the MS. Generally, the original baseline individual activity durations are budget durations, representing the most likely duration for the activity based on the project execution plan and current cost budget. These durations are validated by the Lead Planner against available historical sustained average and peak commodity installation rates, craft labor density analysis and similar techniques. In the development of activity durations, schedule activity duration adjustments, e.g., planner's padding, hidden contingency, stretching to fit the time available, and other reasons for overriding the calculated duration are not allowed, as they detract from the overall schedule's accuracy and utility.

6.4.3.2.9.1 Engineering, Procurement, and Contracts Durations

Baseline engineering durations and unit rates for standard drawings, specifications, etc., are based on historical and current experience on similar jobs and adjusted for project-specific conditions. Baseline procurement durations for purchase order and subcontract formation and fabrication/delivery activities are based on current market conditions.

Baseline contract mobilization durations are determined in coordination with Contract Administration and Engineering and are based on contract type and particulars, including the contracts engineering, material purchase/fabrication, and site mobilization requirements. After award, these durations are updated per contract requirements.

Vendor input durations, such as receipt of vendor information, are initially developed with Engineering and Procurement to reflect realistic durations from purchase order/contract award that support project needs.
Once the Engineering Tracker and Procurement Tracker are operational, duration changes to CS Engineering, Procurement, and Contract activities are identified through changes to the detailed tasks in the Trackers. These changes then map back to the CS activities as described in further detail in section 6.4.3.4

6.4.3.2.9.2 Construction Durations

Construction activity durations are calculated based on man-hours, planned staffing or labor crewing profiles, and any unique intra-activity factors that modify these factors (e.g., multiple shift requirements, crew densities, and site conditions). Durations based on special work regimes, such as night shift are handled through project calendars and noted in the Basis of Schedule.

The following duration formula should be used as the default:

Scheduled duration = [Activity man-hours x 1.5] / [Optimum crew size x daily hours]

This formula accounts for resource profiles that are not constant, considering mobilization to work front of resources and construction equipment, required hold points, topographical surveys, etc.

The formula is over-ridden when historical information or expert judgment provides a better basis for a duration, or if team reviews conclude that a duration can be changed on a realistic basis and rationale.

A team review involves bringing the appropriate team members into a meeting area, displaying the appropriate plans and drawings, and drawing the subject path in CPM-logic-diagram format on the whiteboard. Scheduling contributes to the team in using network analysis and lateral ("out of the box") thinking to improve the plan logic and attain the optimum cost and schedule approach.

6.4.3.2.9.3 Resource and Quantity Loading

The CS is resource loaded with bulk quantities release, delivery and installation, construction installation man-hours, major construction equipment usage (e.g. cranes), in order to generate planned time-phased curves. Current budget hours and quantities are loaded as part of the Original Baseline CS development. Incremental monthly loading of approved trend quantities and man-hours is performed as the project progresses. Forecast man-hours and quantities are loaded as part of major periodic project reforecasts.

Construction man-hours are loaded into the schedule by activity with sufficient coding of each resource to generate varying levels of summary reports. The Lead Planner will determine the level of detail necessary to meet project management and reporting requirements, which may include summaries by craft, discipline, subcontractor, and elements of the project cost account. A portion of the construction man-hours are allocated to completion of punchlist items prior to system/area turnover. Actual expended man-hours are tracked and reported through the Quantity Tracking and supporting reports and curves, not in the CS. Major Equipment usage is loaded into the CS as necessary to effectively schedule its utilization. Bulk commodity quantity release (one activity per work package) and installation are loaded into the schedule by activity with coding that allows generation of varying levels of summary reports by elements of the project cost account structure. Actual released and installed bulk quantities are tracked and reported through the Quantity Tracking and supporting reports and curves, not the CS.

6.4.3.2.10 Bulk Commodity and Labor Resource Curves

Bulk commodity release, delivery and installation, and construction labor early/late curve envelopes are developed and used to validate the scheduled curves generated by the MS. The schedule curve typically lies one-third of the way from the early start to the late start curve generated by the CPM software. This is detailed in Section 6.4.3.2.8.1 – Preferential Logic. Additionally:

- Individual commodity release and installation curves are reviewed to ensure the duration lag between them allows sufficient time for fabrication, delivery, and constructability review. This lag is the result of the logic and structure adopted in the CPM network and is validated by examination of the lag between CS generated early and late release and install curves.
- The quantity release curves generated from the Engineering Tracker detail are checked to verify support of the CS early start release curve.
- The family of early and late commodity installation curves generated by the CS is reviewed by the Lead Planner and project team to validate reasonable phasing between commodities.

When utilizing the Engineering Tracker, loading Engineering man-hours into the CS is not required. The CS phasing requirements drive the Engineering Tracker. Once the Engineering Tracker man-hour loading is approved as a baseline, the CS Engineering phasing is validated.

Cost loading of the CS is not normally required.

6.4.3.2.10.1 Contractual Commitments

All contractual commitments are recorded in the CS, including start, intermediate, and completion milestone dates, and other schedule-related items specified or implied in the contract:

- Contract conditions relating to schedule including Liquidated Damages dates and other Contract milestones
- Entity review and approval activities
- Permit and licensing activities
- Regulatory Approvals
- Access restraints and timing
- Activities by others (contractors engaged directly by the Entity, Entity Operations, etc.)
- Cash flow and other rate of work limitations
- Restricted work periods
- Any phased facility completions required to accommodate entity occupancy/acceptance
- Contractually stipulated durations are used for entity approvals, regulatory reviews, etc. If the contract does not stipulate Entity review and approval durations, the project works with the Entity to obtain written agreement to use standard durations as soon as possible.

6.4.3.2.10.2 Activities/Restraints by Others

The CS contains activities, deliverables, and restraints by partners, contractors, vendors, governments, or other outside agencies that will affect project schedule. These include, but are not limited to:

- Physical access dates

- Licensing and permitting activities
- Vendor information and design

6.4.3.2.11 Schedule Risk Management

A Schedule Risk Management Table is prepared during the proposal phase to identify and document project schedule risks, assess the potential impact of those risks, and outline risk treatments. The table is passed on to the project team and is updated by the Lead Planner and the project team to include any new or changed risks identified in bringing the management schedule from proposal phase to an original project baseline. The Schedule Risk Management Table is subsequently used to manage schedule risks through the life of the project. The risk treatments identified and agreed to by management in the table are included in the CS development. The impact of new risks and risk evolution as the project progresses are included in CS updates.

Once schedule risks are identified as being project critical, they shall be included in the Critical Item Action Report (CIAR) for management action, and noted in the project risk register as necessary.

6.4.3.2.12 Critical Path Analysis

The critical path(s) based on least float is identified in the CS. Critical activities are defined as those having a range of float of less than 1 month per year of remaining execution. This range will vary depending on the project. Critical activities should generally not encompass more than 15 percent of total to-go activities. Management attention should be focused on the paths contained within this range.

The critical and near-critical paths in the Original Baseline CS are based on those identified in the MS during the project schedule development. Any differences between the CS and MS paths are analyzed and management approved. If a new critical or near-critical path is identified by the CS, then a critical path analyses with the team shall be performed.

6.4.3.2.13 Duration Probability Analysis and Schedule Contingency Development

Schedule duration probability analysis and contingency development is performed during MS development and confirmed through further analysis carried out on the CS as baseline and with each forecast and major schedule revision. The schedule contingency derived from the analysis is included as an activity in the CS pre-commissioning, pre-operational testing, or commissioning/handover activities that lead to the contractual project completion milestone. This activity should be clearly identified as Contractor’s schedule contingency.

6.4.3.2.14 Narrative

The schedule narrative is prepared as part of the MS development. When the Original Baseline CS is developed or when a major revision to the CS is made, the narrative is updated to include any significant changes or additions. The project should update and issue the Basis of Schedule document with every major CS revision.

6.4.3.2.15 Revisions and Archiving

The approved Original Baseline CS is Revision 0, and all subsequent baseline revisions shall be numeric.
A copy of the baseline is made once the baseline is approved, and becomes the current schedule. Progress updates and schedule evolution is performed on the current schedule only. Every updating period, a copy of the current schedule is made and archived. A current schedule shall make reference to the Current Baseline and last period update in order to see and analyze overall and period performance.

6.4.3.2.16 Software

The CS is processed using the project preferred scheduling software. This procedure describes the format and content without specific reference to the schedule automation software type or version.

6.4.3.3 ORIGINAL BASELINE CONTROL SCHEDULE DEVELOPMENT

The Original Baseline CS is developed as soon as possible after project award. In some cases and depending on RFP requirements, the baseline schedule is part of the contractor's bid document.

6.4.3.3.1 Timing

The CS is targeted for issue between 1 and 3 months of start of the execution phase Notice to Proceed (NTP), depending on size and complexity of the project.

6.4.3.3.2 Kick-Off Meeting

After the project team's concurrence of the CS development schedule, a kick-off meeting will be held attended by all non-manual project team members to discuss:

- Brief overview of the schedule hierarchy and relationships
- Schedule for the development of the original baseline MS
- Project management's schedule goals/objectives
- Schedule activity ownership – every activity in the schedule has an owner who will be held accountable
- Schedule for CS development and identified responsibilities of the project team members
- Narrative and Basis of Schedule highlights that may include, but not be limited to:
    - Safety and ES&H guidelines and their relationship to schedule
    - Limiting factors driving EPC timing/phasing
    - Entity's strategic issues that influence the project cash flow or work plan and could impact Contractor's schedule
    - Constraints imposed by external agencies or groups that could impact project delivery
    - Contractual requirements and areas of schedule risk
    - Schedule basis and assumptions
    - Schedule contingency requirements
- The interim schedule control process during CS development, including review of front-end schedule activity status and the schedule impact management program
- Any immediate concerns of the project team

6.4.3.3.3 Draft Preparation

Project controls prepares the draft Original Baseline CS according to the development schedule using the approach described in Section 6.4.3.

Responsibilities for almost all activities in the schedule development process are shared between project controls and the supervisors responsible for doing the work. The draft preparation process should include review and validation by the planner at each step of the process. The remainder of this section is organized by development schedule activities.

6.4.3.3.3.1 General

Gather Schedule Basis – As soon as the CS development effort begins, project controls gathers the schedule bases per the CS Source Documentation Checklist. This includes identification of any and all available Entity templates/standards/historical documents.

Develop CS Infrastructure – Prior to defining CS activities, the project scope is divided into work packages. A structure is developed for organizing the schedule activities by activity code. Project execution resources are identified or defined. Optionally, projects may also develop a WBS and/or an OBS to assist in organizing the work. The project manager and functional leads review and agree to work package definition.

Develop Fabrication and Modularization Schedule –The Lead Planner may develop a fabrication and modularization schedule to support the off- site work requirements identified in the Contract Strategy and Project Execution Plan (PEP). The fabrication and modularization schedule is prepared at a Level 2-3 and addresses work scope that will be completed at fabrication facilities and includes modularization and traffic and logistics requirements.

Develop Temporary Facilities Schedule –The Lead Planner may develop a front-end schedule to support the requirements for temporary facilities. This schedule is prepared at a Level 2-3 and addresses work scope that will be completed during the initial months of the project, including such items as camps, training facilities, site roads, laydown areas, wharfs and airports, etc.

Develop Front-End Schedule –The Lead Planner may develop a medium term, 90 Day schedule for temporary control of the project during CS development. The front-end schedule is prepared at a Level 2-3 and addresses work scope that will be completed during the initial months of the project, including:

- Project setup
- Front-end engineering activities
- Long-lead purchase order and subcontract formation activities
- Execution plan finalization
- Management schedule finalization
- Procurement Tracker development
- Engineering Tracker development
- Any other significant work

The front-end schedule is issued as soon as possible after the start of the relevant work phase, no later than 2 weeks, as shown on the CS development schedule. At a minimum, front-end schedule review meetings are held once every 2 weeks. Note that the CS is typically developed at the start of the execution phase of a project. This occurs at NTP in a typical commercial bid cycle, but may occur earlier than NTP in the case of a study, project with early construction works phase, or as part of the bid cycle.

Contractual Commitments, Management Milestones, and Activities/Restraints by Others – All contractual commitments, management milestones, and activities/restraints by partners, contractors/vendors, governments, or other outside agencies are identified and included in the schedule.

6.4.3.3.3.2 Engineering/Procurement/Contracts

Develop Initial MR Register – Per the MS and Construction's input, Procurement prepares the initial MAS based on initial Required On Site (ROS) dates provided by project controls. The Lead Planner and project procurement manager review the MAS to identify items requiring lead time verification or vendor quotes.

Develop Initial Contracts Register – Per the MS and Construction Management input, contract formation prepares the initial Contracts Register based on initial ROS dates and contract milestone dates provided by project controls. The Lead Planner reviews the Contracts Register to identify items requiring further study, for instance first of a kind construction techniques or specialist construction equipment. Level 2 Contract installation schedules are developed.

Engineering/Procurement/Contracts Essential Logic Fragnets – Essential logic fragnets are developed by the Entities based on Entity standards and processes, where available.

Engineering Release Resource Loading – A/E Engineer to provide key commodity release curves based on resource loaded A/E schedule or Engineering Tracker. This is especially important if construction contracts initiate construction works ahead of design engineering completion.

Integrate Engineering/Procurement/Contracts Fragnets – Essential logic to completely integrate engineering, procurement, and contracts is added to the schedule. Project Controls reviews key dates to

ensure they support the MS. Project controls reviews the dates for work package IFF/IFC, material delivery, and contract award to determine if they support their initial early start date requirements from construction (see Section 9.4.3.3, Construction/Commissioning). Engineering/Procurement/Contracts may be unable to support some of the initial early start date requirements. These issues are identified for relief consideration by Construction during the addition of preferential logic to the construction schedule, and subsequently addressed at the EPC integration meeting(s). After initial review by Project Controls, the fragnets are reviewed by the project engineer, project procurement manager, and project subcontract manager and/or their delegates. The reviews are ideally in the form of time-scale logic diagrams.

6.4.3.3.3.3 Construction / Pre-Operational Testing & Commissioning

Each of the following items is developed and reviewed against the MS by project controls and agreed to by the construction manager and/or their delegate (e.g. area/discipline superintendents). Logic and duration reviews are ideally in the form of time-scaled logic diagrams. Specific additional approvals are noted below.

Front-end Essential Logic Fragnets – Includes development of activities, logic, and durations for the initial construction activities onsite, e.g., piling and site preparation, underground work, foundations, etc.

Construction System/Facility Turnover and Pre-Operational Testing Turnover Fragnets – Project controls develops construction system turnover, Pre-Operational testing, and project completion fragnets. The results are reviewed and agreed to by Project, Construction, and Pre-Operational Testing managers. These fragnets may initially be generic based on Entity standards that are defined later in the project as operational systems are defined against Flow Diagrams, P&ID's and Single Line diagrams and the component level information.

Structural and Equipment Essential Logic Fragnets – Follow-on fragnets from initial construction activities (e.g. structures and equipment) are developed and linked to initial construction predecessor and system/facility turnover or other construction successor activities.

Bulk Commodity Essential Logic Fragnets – Bulk commodity fragnets are developed and linked to construction predecessor and system/facility turnover successor activities.

Resource Load Construction Schedule – Construction activities are loaded with manual man-hours, major construction equipment, and bulk quantities. Resource allocation per activity will have been initially considered as part of each activity duration development. Resultant staffing and installation curves are reviewed against the MS.

Initial Work Package IFC, Material, and Subcontract Award Need Dates – The construction Lead Planner identifies initial work package IFC/IFF, material ROS dates, and subcontract award early dates based on construction CS development to date, which includes essential logic only.

Construction Preferential Logic – Construction preferential logic is added and reviewed to ensure that it does not impact required handover dates to startup. Attempts are made to resolve instances where the Engineering / Procurement / Subcontract schedule is unable to support the initial construction work package IFC, material ROS dates, and subcontract award need dates. The resultant labor and installation curves are reviewed to validate phasing with the end result being a schedule phased ahead of the MS. Agreement of schedule phasing includes agreement by the construction manager to the final resultant logic, activity durations, staffing, and installation curves.

6.4.3.3.3.4 EPC Integration

Prior to linking the Engineering/Procurement (EP) and Construction/Pre-Operational Testing schedules, the two portions are essentially complete, with the exception of EP preferential logic, and are validated as independently supporting the MS.

Integration of Engineering/Procurement/Subcontract with Construction/Pre-Operational Testing & Commissioning – As integration logic is added, float at the interface points is checked to identify potential problem areas. Interface points include:

- Engineering issues MR to Procurement to purchase material and subcontracts
- Engineering work package issuance to construction

- Material deliveries to construction
- Subcontract award/mobilization
- Permit availability
- Engineering issue for customer or third party ROW

If the float is more or less than expected, project controls checks that the logic and durations leading to the interface points is correct. Where the timing at an interface point is not acceptable (e.g,. indicates negative float), the following resolution process is used:

- Project controls works with the persons responsible for the work within each phase to validate the logic and, if necessary, attempt to shorten the durations within the phase(s). Never adjust logic or reduce a duration to resolve an issue without a supportable basis.
- When a solution cannot be found by adjusting logic or shortening durations within one phase or another, the issue is brought forward at the EPC integration meeting. The integration meeting includes Lead Planner, the project manager, the functional leads, and support personnel who meet in a whiteboard setting to resolve the issue(s). The ultimate arbiter is the project manager.
- If the issue requires a change in the execution plan that will result in increased cost, or in an increase in project schedule duration, the issue is managed via the schedule impact management and trend process.

Engineering/Procurement/Subcontracts Preferential Logic – Preferential logic is added to the Engineering/Procurement/Subcontract schedule once EPC integration is complete. Schedule phasing requires agreement by the project engineer, project procurement manager and project contracts manager for final resultant logic, activity durations, and production and delivery curves. Any schedule conflicts with construction generated via the addition of engineering / procurement / subcontract preferential logic, is dealt with as described above.

Critical Path Optimization – Critical and near-critical path optimization is performed after EPC integration is complete. If significant changes to the MS critical path occur as a result of CS development, schedule probability and contingency analysis is revisited.

6.4.3.3.3.5 Internal Review and Approval

Once the draft Original Baseline CS is substantially complete and scheduling has performed the validation reviews described in Section 6.4.3.3.3, the CS undergoes a project team review.
Comments to the draft schedule should be minimal, as at this point each team member's input should have been included via the review meetings held during the draft development.

The main purpose of the project team review is to confirm ownership and get project team buy-in to the Original Baseline CS schedule. The project team review package is supplied to all project team members who are responsible for performing a portion of the work. As the comments are expected to be minimal, turnaround time for comments is short, typically one or two days.

A typical project team review package Original Baseline CS includes:

- Cover letter requesting comments or positive buy-in within turnaround time
- Current Management Schedule (MS)
- Narrative describing any significant variance from the MS and associated reason for the variance
- Critical and sub-critical path schedules
- Engineering discipline schedules
- Engineering production/release curves
- Engineering staffing curves – from or based on Engineering Tracker
- Engineering progress curves – from or based on Engineering Tracker
- Procurement schedules
- Procurement production/delivery curves
- Construction area schedules
- Construction discipline schedules
- Construction labor curves
- Construction quantity installation curves
- Pre-Operational Testing/Commissioning schedule

Subsequent to the review and incorporation of the project team and Entity project controls functional comments, Project controls confirms project manager acceptance and approval for issue of the Original Baseline CS. The Original Baseline CS package, similar in content to the project team review package, is then issued to the project team with a cover letter signed by the project manager. The package is transmitted during a team meeting at which the project schedule control program is outlined to the project team. Contractor begins using the CS as a project schedule management and control tool at this time.

6.4.3.3.3.6 Entity Approval

Contractor submits the CS for Entity approval, or acceptance as required by Contract, under a cover letter signed by the project manager. Entity comments on the schedule should be limited to compliance with the contractual schedule milestone and technical specifications. Comments on Contractor means and methods may be considered, but Contractor is not obligated to consider or incorporate them.

6.4.3.4 MAINTENANCE OF LEVEL 3 CONTROL SCHEDULE

The proper maintenance of the CS is essential to management's ability to control the project schedule and the project's financial well-being. The CS is the contractual basis for benchmarking schedule impacts and changes, and this can only be done if the CS reflects the actual and current schedule status at the time a change event occurs. The CS 'directs' all the project's Level 5 Trackers, and provides the reference for allocation of priorities, manpower and other resources, expenditure on acceleration, and workaround and recovery plans.

6.4.3.4.1 Current Control Schedule Update

The CS is updated monthly with progress generated from the Level 5 Trackers. Schedule status is generated according to the following guidelines.

Frequency and Timing – The schedule is formally updated at the end of a calendar month. However, as progress information is identified via the Engineering / Procurement Short-Term Work Plan, the Construction / Commissioning Implementation Schedule Tracker, and Schedule Critical Items Action Report meetings, project controls runs what-if scenarios using the CS to identify the effect of delays and test recovery plans.

Activity Durations – Activity durations are progressed by updating the remaining duration or actual dates. This information is gathered from the multiple activities in the lower level schedules that map to the CS.

- Engineering: CS work package durations are updated by reviewing the work package status report or the individual engineering deliverable start and finish dates generated from/contained in the Engineering Tracker.
- Procurement: Remaining durations and actual dates are identified from the Procurement Tracker milestone(s) associated with the CS activity. In cases where a Procurement Tracker report is not available, the remaining durations are supplied by the procurement representative responsible for the work.
- Construction: Status is identified manually from the last four-week schedule activity. Where the completion date is outside of the four -week window, the completion date is supplied by the responsible superintendent / subcontractor.
- Pre-Operational testing: Status is identified manually by the Lead Planner from the Pre-Operational Testing working schedule, or is supplied by the responsible Pre-Operational Testing engineer.

Percent Complete – Typical methods for generating CS activity percent complete are as follows: Note that a default percent complete is not linked to remaining duration except for Level-of-Effort activities.

- Engineering: If Engineering Tracker is used, the Engineering Tracker report generates the aggregate percent complete (actual earned/current budget) for the multiple Engineering Tracker activities mapped to each CS activity. Alternately, percent complete can be calculated based upon the remaining duration extracted from the Engineering Tracker.

- Procurement: For standard percent complete associated with each step in the purchase order and subcontract BEA cycle, progress can be determined from Procurement Tracker (or other) reports and the percent complete assigned to the CS activity.
- Construction: Contractor standard approach is to use the Quantity Tracking in deriving the percent complete based on quantities installed in direct works versus the total direct works quantities. The percent complete is calculated from actual earned direct hours divided by total scope direct man-hours when the information is readily available at the schedule activity level. However, this information is typically available for every schedule activity and level of detail, and significant effort should not be expended to generate it.
- Pre-Operational Testing and Commissioning: Percent complete is estimated by the responsible Pre-Operational Testing engineer. Project controls checks for accuracy.
- Level-of-Effort: Percent complete is calculated as actual duration divided by total forecast duration.

Logic – Logic changes associated with schedule updates may include:

- Preferential logic modifications to account for evolving progress / priorities and incorporation of workarounds. Care must be taken not to create uneconomic working conditions or hide the true effect of impacts or delays through such changes.
- Logic associated with changes.
- Logic to accurately illustrate the effect of delays or impacts.
- Correction of logic errors.

Change Incorporation – All contract change orders submitted to the Entity that Contractor has approved for execution (but are not necessarily approved by the Entity), and approved trends (including Contractor approved schedule impact recovery measures) during the current reporting period, are incorporated into the schedule. Incorporation of trends and scope changes include updating the activity resource loading. During the first update cycle after Original Baseline CS approval, all approved other (non-scope) trends are incorporated into the schedule.

Schedule Contingency – Schedule contingency is included as a single, identified activity at the end of the schedule. Contingency is allocated to resolve a schedule impact only after a recovery study shows it to be the least costly alternative.

Target Schedule – The Original Baseline CS is typically used as the target schedule. As the project evolves, it may be modified to address change. Any revision to the target schedule must be documented and leave the contractual milestones unchanged, unless there is an Entity-approved change order that affects them.

6.4.3.4.2 Analysis – Impact and Delay

Once the schedule has been re-calculated based on the periods input, the variance from the previous schedule update is identified by finish date and float erosion. The planning department reviews and acts upon variance as follows:

Critical Path Delays - Any float erosion on critical or near-critical path is validated with the person responsible for the work execution or for providing the schedule input. If validated, the Lead Planner works in conjunction with the person providing the schedule input and identifies the issue to the responsible department lead or supervisor. The issue is analyzed to identify a simple workaround or resolution. If a solution is found, the CS is adjusted accordingly. If a simple solution cannot be found, the issue is evaluated through the Schedule Impact Management process as necessary.

Significant Non-Critical Path Delays - For float erosion not affecting a critical or near-critical path but of a non-trivial and undesirable nature (in the scheduler's estimation, the path does not have comfortable float) the process of attempting to find a simple solution as described above is followed. However, that if a simple solution is not found, the issue is not elevated to the Critical Items Actions Report (CIAR), but is instead addressed in the next schedule review meeting. Items of this type generally include, but are not limited to, delays to any material delivery, contract award, subcontractor mobilization date, work package IFF/IFC, or construction turnover of a startup system.

Insignificant Delays - Float erosion of inconsequential nature, such as delay to a path with a comfortable float that is not associated with work having a potential or real cumulative impact to the work, requires no action.

6.4.3.4.3 Reporting

Project Controls prepares a monthly schedule report package that combines MS and CS reports. An important feature of the package is the CS display of activity owner, finish variance from the previous update, and comparison to the current benchmark in terms of finish variance and float. The electronic CS database and the hard copy report package are archived upon conclusion of each update cycle. The CS portion of the monthly report contains the following excerpts:

- **Critical and Near-critical Paths** – Critical and near-critical paths compared to the current benchmark schedule
- **Milestone Report** – All project milestones versus current benchmark schedule
- **Pre-Operational Testing and Commissioning Summary Schedule** – Construction system turnover to Pre-Operational Testing and Commissioning, shown as one activity per operational system and successor activities through to project completion (may be omitted in early stages of project, unless variance occurs during the update cycle).
- **Three-month Lookahead** – Activities for the previous month and for the next three months versus the current benchmark schedule
- **Stakeholder Report** – Extracts tailored for specific stakeholder groups. These reports vary depending on the project and typically include:
    - **Engineering Deliverables** –Engineering deliverable interface points with Procurement, Subcontracts, Construction, Entity, and any outside agency (e.g., MRs, work packages)
    - **Procurement Deliverables** – Procurement deliverable interface points (e.g., vendor information, deliveries) with Engineering, Construction, and the Entity
    - **Subcontract Deliverables** – Subcontract deliverable interface points (e.g,. awards, vendor information, deliveries, mobilization) with Engineering, Construction, and the Entity
    - **Construction Deliverables** –Construction deliverable interface points (e.g., startup system and facility turnover) with Startup and the Entity
    - **Commissioning Skyline** – Stacked bar chart showing system turnover by week
- **Bulk Commodity and Staffing Curves** – Updated and issued monthly as part of the MS update. On projects with biweekly CS update cycles, some portion of the bulk commodity and staffing curves may be updated biweekly or weekly for critical areas as deemed necessary by the project

- **Narrative** – Cover document to the schedule package that provides an analytical summary of the current period update, including:
    - **Current schedule status** with respect to financially significant completion and other milestone dates, including those associated with the current budget, contractual liquidated damages, and any early completion/target schedule dates. The section also includes a discussion of any real or potential schedule impacts associated with these milestones
    - **Summary of changes** from the previous update including:
        - Changes in critical path
        - Delays in material deliveries or contract awards
        - Work package IFF delays
        - Work package IFC delays impacting construction activity start dates
        - Delays in startup system/facility turnover dates from Construction to Startup
        - Delays in startup system/facility turnover from Startup to Entity
    - Significant changes in resource requirements (e.g., due to quantity increases)
    - Changes to qualifications and assumptions

6.4.3.4.4 Monthly Schedule Review Meeting

A monthly schedule review meeting is held to examine the contents of the monthly schedule report. The focus of this meeting is the three-month lookahead schedule. The meeting covers issues related to schedule achievement that are not covered in the weekly Construction Tracker and Engineering / Procurement Short-term Work Plan meetings due to their near-term focus (e.g., float erosion on near-critical paths or potential cumulative impacts that are not on the CIAR). This meeting is independent from any monthly progress review meeting that projects may hold to review the contents of the Monthly Progress Report.

6.4.3.4.5 Project Schedule Forecasts

The CS is the vehicle for performing project forecast schedule reviews. Verification of the forecast CS durations is required prior to forecast approval.

6.5 LEVEL 4 – SUBJECT MATTER SCHEDULES

6.5.1 PURPOSE

The purpose of creating and maintaining a Level 4 schedule is to address specific situations that demand greater level of study and detailing than normally performed on Level 3 schedules.
Because these types of schedules are optional and developed as needed, these are not normally integral part of the schedules updating cycle, but certainly can be if warranted.

6.5.2 SCOPE

Reasons to develop a Level 4 Subject Matter Schedule can be:

- Initial mobilization schedules
- Short term (i.e. 3 month) more detailed lookahead schedule
- More detailed schedule to study interfaces on coordination requirements with other entities or contractors
- More detailed schedule to plan and track complex or specialized constructive sequences

6.5.3 PROCEDURE

Formatting for Level 4 schedules is flexible as long as it supports the needs of the subject matter at hand.

6.5.3.1 Application Software

It is recommended to use the same CPM software application as for Level 3 control schedule.

6.5.3.2 Development

As with any plan and schedule, it has to be developed by the team. Planners and schedulers perform supportive roles. Planners and schedulers have to make sure that team's plan fits within the contractual or target timeframes of the overall schedule, and adjust overall schedule as necessary.

6.5.3.3 Maintenance

A decision needs to be made if a particular Level 4 schedule is to be maintained. If that is the case, it needs to become part of the Level 3 updating cycle and serve as input to the Level 3.

6.6 LEVEL 5 – DETAILED TRACKERS

6.6.1 PURPOSE

The purpose of creating and maintaining Trackers (Level 5 schedules) is to monitor plan, status and forecast at the lowest practical level of detail to help the team plan, schedule and execute the work.

These types of schedules are key to quantify the work as they encompass full sets of deliverables, like engineering deliverables, full quantities of key commodities, systems, etc.

6.6.2 SCOPE

Trackers (Level 5 Schedules) are required to:

- Understand quantities involved
- Plan and track progress at detailed level
- Early identification of deviations to plan

6.6.3 PROCEDURE

Trackers are maintained by their respective departments. The base trackers are:

6.6.3.1 Engineering Tracker

- Maintained by Engineering
- Lists all engineering deliverables
- Lists baseline, actual and forecast dates for all deliverables
- Provides a % complete calculation, per document, department and overall
- Refer to document EPM-KPC-PR-000005 Project Engineering Tracker Procedure for more information.

6.6.3.2 Procurement Tracker (listing all Material Requisitions / Purchase Orders)

- Tracks formation of every Purchase Orders starting with MR (Material Requisition) by Engineering through award of Purchase Order by Procurement.
- Maintained by Procurement
- Lists all Material Requisitions to be generated by Design Engineering
- Refer to document EPM-KPC-PR-000006 Project Quantity Tracking Procedure for more information.

6.6.3.3 Delivery Tracker (listing all Deliveries)

- Maintained by Procurement or Expediting
- Lists all Procurement Deliverables, including Vendor Information
- Refer to document EPM-KPC-PR-000006 Project Quantity Tracking Procedure for more information.

6.6.3.4 Quantity Tracking (listing all quantities and related installation man-hours)

- Maintained by Construction
- Lists all quantities to be installed
- Has budget and earned quantities, and budget, spent and earned job-hours to install those quantities.
- Provides a Cost Performance Index (CPI), based on man-hours

- Refer to document EPM-KPC-PR-000006 Project Quantity Tracking Procedure for more information.

6.6.3.5 3-Week Lookahead

- Maintained by Construction
- Refer to document EPM-KPP-PR-000007 Project Schedule Lookahead Procedure for more information.

6.6.3.6 Other

Other types of trackers shall be implemented if relevant to the project, like:

- Tie-in tracker
- System Turnover Tracker
- Punchlist Tracker
- …

7.0 ATTACHMENTS

N/A