اجراپذیری برنامه زمان‌بندی (Schedule Constructability)

فرآیند + چالش‌ها + چکلیست‌ها

(بر اساس اسنادی از AACE + Long International)

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What we will learn?

- Purpose
- Recommended practice
  - Background
  - Schedule constructability review
  - Schedule constructability reviews during the various phases of a project
    - ✓ Design Phase
    - ✓ Procurement Phase
    - ✓ Execution Phase
  - Schedule Constructability Review Considerations
  - Site Planning Development
  - Schedule Constructability Review Checklist
  - Site Construction Schedule Checklist

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What we will learn?

- Schedule quality assurance procedures
  - Scope of the project schedule
  - Schedule metrics comparison
  - Schedule logic review
  - Critical path evaluation
  - Project schedule update comparisons
- Schedule quality and deficiency check examples
- Schedule quality assurance services

Reference

Primary reference

AACE® International Recommended Practice No. 48R-06

SCHEDULE CONSTRUCTABILITY REVIEW

TCM Framework: 7.2 – Schedule Planning and Development
11.5 – Value Management and Value Improving Practices (VIPs)

Rev. August 28, 2009

Note: As AACE International Recommended Practices evolve over time, please refer to web.aacei.org for the latest revisions.

Any terms found in AACE Recommended Practice 10S-90, *Cost Engineering Terminology*, supersede terms defined in other AACE work products, including but not limited to, other recommended practices, the *Total Cost Management Framework*, and *Skills & Knowledge of Cost Engineering*.

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Why constructability important?

- Many project schedules are often **poorly prepared** and require extensive rebaselining during project execution to become a useful project management tool to
  1. Properly measure progress,
  2. Determine the effect of changes in scope, and
  3. Forecast the completion of contractual milestones and overall project completion dates.
- **Poorly prepared schedules** do not provide a reliable tool to measure the amount and **responsibility for delays** that occur during project execution to
  1. Provide a basis for a time extension or
  2. Assess the need for acceleration to mitigate delays

What are the purposes of this guideline?

Purpose

Purpose of This RP

- This recommended practice (RP) is intended to serve as a **guideline**, not establish a standard for schedule constructability reviews.
- This recommended practice describes
  1. The schedule constructability review (SCR) **process** and
  2. Some of the **recommended planning** that should be considered when developing a construction **project execution-phase schedule**.
- This recommended practice includes a **suggested review process** for the construction project schedule.
- This RP was written as a **stand alone document** however it can be used as a companion guideline with the **AACE Recommended Practice 30R-03** Implementing Project Constructability.

Why do we need to have the similar guideline in our project?

Recommended Practice
(Background)

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Introduction

- Construction contract **schedule specifications** frequently require **reviews** of the project baseline schedule

  with very **little guidance** about how that review process should be accomplished.

- There may be **contract language** that suggests the **"schedule should be consistent with the project scope"** and

  that there should be an **appropriate level of detail** to facilitate integration of the **various contractors or trades**.

How this document prepared?

Introduction

- **Numerous technical articles** have been published that recommend **analyzing** the project cost and schedule.
- **Several of those articles** describe a recommended process for the **detailed analysis** of construction project cost estimates.
- It was **difficult** to locate **comparable information** from these **technical resources** that describes the **process** to analyze the construction project schedule.
- Constructability review checklists that were located assume an understanding of **what is required by an SCR** and **barely mention** the need to perform a construction schedule assessment.

What does constructability mean?

Constructability

- The **Construction Industry Institute (CII)** and **AACE International** define

*"constructability [as] the **optimum use** of*

1. *Construction knowledge and*
2. *Experience*

in

1. *Planning,*
2. *Design/engineering,*
3. *Procurement, and*
4. *Field operations*

*to **achieve overall project objectives**."*

What does constructability review mean?

Constructability review

- A **constructability review** is a structured review of the **plans** and **specifications** with the focus on the buildability, biddability and efficiency of construction.

- **Constructability reviews** are performed to **assure consistency** between design, fabrication, and installation.

- These reviews identify errors, conflicts, and omissions and as a result of constructability reviews **future costly field changes** can be minimized.

Constructability review

- A constructability review is the **process** of evaluating the **construction documents** (design drawings, and technical specifications) for
  1. Clarity,
  2. Consistency,
  3. Completeness, and
  4. Ease of construction

  to achieve overall project objectives.

What is the objective of constructability review?

Constructability review

- The objective of this review is to provide clarity, consistency, and completeness of the contract documents to facilitate
  1. Construction bidding,
  2. Administration, and
  3. Interpretation

  to achieve overall project objectives.

*Constructability reviews are performed as a **cross check** of construction documents for accuracy, completeness, and systems design coordination issues.*

What factors influence constructability review?

Factors influence the effectiveness of a constructability review program

- **Several factors** influence the effectiveness of a constructability review program:
  1. Project delivery system,
  2. Project contracting strategy,
  3. Procurement strategy for material and equipment,
  4. Completeness of the project scope definition.

What should be considered in constructability review?

General considerations in constructability review

- Constructability reviews **generally consist** of:
  - Construction involvement during project design;
  - Detailed project scope review;
  - Detailed review of construction plans and specifications;
  - Execution plan development and review;
  - Detailed schedule and budget review; and
  - Development of identified alternatives.

What should be improved in constructability review?

Improvements during constructability review

- During the constructability review, the **focus is on improving**:
  - Consistency, clarity and completeness of the construction drawings and specifications
  - Consistency, applicability, enforceability, and comprehensiveness of the general condition
  - Applicability of construction installation technology, methodology or materials
  - Consistency between plans and site conditions
  - Identification of project-specific issues, their probable consequences, and proposed mitigation recommendation.

What is the application of constructability review?

Application of constructability review

- The application of constructability concepts to capital construction projects have been **reported to provide** a return on investment of **at least ten to one (10:1).**

- Implementing project constructability concepts **reduces** project costs and schedule while having a **positive impact** on quality and safety.

Application of constructability review

- According to studies the implementation of constructability reviews and assessments **at all stages** of the project from conception to commissioning have been shown to provide opportunities to identify **both** cost and schedule savings for the project.

- Early involvement of construction industry experience can reduce or eliminate problems, by

  identifying potential conflicts and

  facilitate a balance between production requirements and building site constraints.

So how about schedule constructability review?

Schedule constructability review

- While the implementation of a constructability review program **can be difficult** it can be **even more difficult** to establish a formal schedule constructability assessment program.

What is schedule constructability review?

Schedule constructability review

- A **schedule constructability review** is performed to **analyze** and **assess** the feasibility of the construction plan.

- The SCR compares the planned sequence of work with the project scope as defined in
  1. The work breakdown structure (WBS),
  2. Site requirements, and
  3. The specific needs of the client.

This RP will focus on …

Focus of this RP

- This recommended practice will focus on **constructability concepts influencing** the construction execution planning and a **suggested review assessment** for the construction project schedule.

Recommended Practice
(Schedule Constructability Review)

Schedule constructability review

- The primary objective of an SCR is to determine if the project schedule is "accurate, logical and achievable."

Schedule constructability review

- The focus of an SCR is to assess the following:
  - Consistency of the **work sequence**
  - Clarity of the **work sequence**
  - Completeness and reasonableness of the **work sequence**
  - **Coordination** of the schedule with the various **engineering disciplines**
  - **Coordination** of the schedule with the requirements for efficient start-up, and commissioning
  - Coordination and **interface** among the various craft trades and engineering disciplines
  - Adequacy of **lead time** for material and equipment procurement
  - **Site restrictions** and adequacy of **site access**

Recommended Practice

(Schedule Constructability Reviews During the Various Phases of a Project)

Introduction

- The **expectations** for accuracy, completeness, and the level of construction schedule detail will **increase** with development of the project through the various phases from pre-construction planning time line through to detailed execution schedule for construction.

Where to start?

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Introduction

- It has been **recommended** that the SCR process should be implemented in **"vertical slices"** for each discipline or major feature of work.
  - For example a **vertical slice** through the **site civil work** would include
    all engineering and design disciplines
    as well as the civil and underground (mechanical & electrical) contractors.
  - **Changes and additions** would then be implemented
    before reviewing the next vertical slice.
  - The final review would encompass the entire project with all project participants, contractors, engineering design, and procurement represented.

Different phases to prepare schedule

Conceptual or feasibility phase

- The conceptual or feasibility phase schedule could be expected to consist of
  1. A **dozen key milestones** and
  2. Possibly a **bar chart** of the significant project activities.
- **Later** into the project pre-construction planning **before** the execution phase, there would be a **high level of detail** to identify the hundreds (or possibly thousands) of activities **required to complete** the construction and installation of the multiple features and systems for the **startup and operation** of that type of facility.
- In some industries such as the process industry, there would be a **numeric classification** assigned to the schedule as the **project scope definition** is developed.

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Design phase

- As project planning and design progresses beyond the conceptual phase, schedule activities will be **added** to identify the important features of work:
  1. **Site areas** to be modified (cleared, excavated, shored, underground utilities, etc.);
  2. Then **key equipment** to be installed and **major systems** to be operationally tested

  will be included as the schedule is **developed during the design phase**.

What is the intention of design phase construction schedule?
Is this master schedule?
What is the difference between this schedule and design schedule?

Design phase

- Although the design phase construction schedule is intended to

  ultimately guide the **construction contractor (or entity)**

  who will perform the construction work,

  1. These schedules have a tendency to **represent the work** at a **higher level (with less detail)** and
  2. May **not portray** accurate estimated durations for construction success.

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Design phase

- The duration inaccuracies in the design phase may occur due to a **lack of accurate quantity details.**
- Design phase construction schedules will typically identify
  1. Key construction milestones and
  2. Construction phase activities

  that portray the **overall plan** for the client.

Does it link specific detailed craft interfaces?

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Design phase

- However the phases within these schedules may overlap
  but generally **do not link** the specific detailed craft interfaces.

- Key equipment installations may be included at various construction points,
  but often the **deliveries** are inaccurately forecasted
  due to a **failure** to verify realistic equipment fabrication and delivery schedules.

- The **level of detail** for a construction schedule can be expected to **increase** in complexity during the design phase for a construction project.

When to perform SCR?

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Design phase

- An **SCR** can be performed at <u>any of the key design completion phases</u>:
  - Schematic design,
  - Detailed design,
  - Etc.,

  corresponding with various stages of <u>construction document completion</u> **(30%; 60%; 90% 100%).**

Traditionally a constructability review will be conducted <u>after the construction documents</u> are complete and <u>prior</u> to **contractor bidding**.

Should the bidder submit proposed schedule?

Procurement phase

- Depending upon the **requirements** outlined in the request for proposal (RFP),

  potential construction bidders may be required to provide a detailed procurement/fabrication and construction schedule

  with their proposal for the construction project.

- That **proposal construction schedule** must consider
  - Vendors input
  - Project and site requirements, and
  - Specific needs of the client.

Should we perform SCR here?

Procurement phase

- An **SCR** of

  these **potential bidders** along

  with the proposed procurements in relation to their construction schedules

  can be appropriate and beneficial **prior to** the construction contract award.

Execution phase

- The project construction execution phase schedule represents

  construction entity's means and methods

  for successfully accomplishing the construction work.

Should we perform SCR here?

Execution phase

- A **constructability review** of the execution phase schedule is intended to
  1. **Compare** the schedule with the entire scope of the project construction efforts and
  2. Should be **conducted prior** to the owner's acceptance/approval of that construction schedule.

What should be mostly assessed?

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Execution phase

- The execution phase SCR can **assess a variety of items** that could affect the time phased plan for **performance of the work**:
  - Physical limitations of the work site
  - Material and equipment “lay down” and storage area requirements
  - Availability of job site utilities
  - Interfaces with the public domain, other construction contractors, and other entities
  - Availability and completeness of design documents and drawings
  - Limitations and restrictions on hours of operation
  - Seasonal influences on the work; local holidays and other factors affecting productivity rates
  - Physical limitations of construction equipment

Execution phase

- The execution phase SCR can **assess a variety of items** that could affect the time phased plan for **performance of the work**:
  - Physical limitations and "handle-ability" of construction components
  - The owner's operational requirements
  - Interfaces and coordination with utility companies
  - Availability of labor, equipment and materials; long lead time equipment items
  - Site safety and security; safety and security of the general public
  - Traffic impacts
  - Aesthetics and safety aspects of barriers and buffers
  - Noise mitigation

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Execution phase

- The execution phase SCR can **assess a variety of items** that could affect the time phased plan for **performance of the work**:
  - Job site cleanliness and maintenance requirements
  - Construction cost and schedule
  - Pay item structures and quantities
  - Quality control, quality assurance, and system testing requirements

Should assessor be knowledgeable about technical stuff?

Recommended Practice

(Schedule Constructability Review Considerations)

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Who should assess?

- The **schedule review** must be conducted by someone who is **knowledgeable** and **understands** the construction requirements of the project.
- The schedule review must be conducted by a **person or persons** with experience in the unique requirements for that **type of project** whether it is
  - General commercial facility;
  - High rise building with unique vertical construction requirements;
  - Horizontal or linear construction such as highways; or
  - Specialized projects such as tunnels, bridges, waste water treatment facilities, brownfield sites, sports stadiums, casinos, expensive custom homes, railroads & transit projects, or power plants, etc.

What two primary roles affect the assessment?

Activity durations

- Schedule **activity durations** are partially established by
  1. Consideration of the quantities to be installed from the cost estimator's drawing take off,
  2. As well as other project factors that might affect productivity such as **site congestion or seasonal impacts** which can better be determined by an experienced constructor.

Is it enough that the assessor be a scheduling professional?

Importance of knowledge beyond scheduling

- The constructability schedule reviewer is **often not a scheduling professional** but must have an **understanding** of

  good scheduling practices and generally accepted principles

  for **"building" the schedule** that accurately represents the

  sequence and logic of how the project will be built.

Important considerations for the constructability schedule review?

Important considerations for the constructability schedule review

- **Completeness.**
  - The schedule must be comprehensive in **scope** including all predecessor and successor work activity relationships **from the construction notice to proceed (NTP)**, mobilization, execution and on through demobilization.
- **Coordination.**
  - The schedule must take into account the **coordination and interfaces** with all project participants.
- **Start-up and commissioning.**
  - The schedule must be **integrated** with the **requirements** for start-up, commissioning and transition to efficient operations of the facility and support systems.

Important considerations for the constructability schedule review

- **Identification of work done by others.**
  - Craft trades; subcontractors; vendors and suppliers; and work performed "by others" must be **clearly indicated** for appropriate clarity in the plan.
- **Control points.**
  - Engineering & design **completion requirements** should be indicated in the **scheduled sequence** as a milestone such as

    "issued for construction (IFC) design documents".
- **Safety, security and environmental requirements.**
  - The schedule should take into account the **special** safety, security or environmental requirements **above and beyond** the generally accepted standards.

Important considerations for the constructability schedule review

Long lead items.

- Material and equipment procurements should be a **major focus** during the construction schedule assessment.
- Adequate lead time for material and equipment procurements is essential.
- The evaluation of **procurement advantages** of using prefabricated, preassembled and modularized components is very important to be resolved early in order to **avoid potential design impact**.
- The **source** of the established durations for ordering, fabrication, and shipping time needs to be **verified**.
- **"Just in time" delivery** is an important concept to keep in mind during the planning.

Important considerations for the constructability schedule review

- **Long lead items.**
  - The **impact of late deliveries** is obvious in the delay potential for the project.
  - The impact of **"too early" delivery** of materials and equipment can be just as significant:
    - Requiring additional storage and laydown areas;
    - Protection from the weather or damage in storage location;
    - Multiple handling of the material;
    - etc.
  - On **more than one project**, the constructor has incurred significant costs and inefficiencies related to longer than planned storage and warehousing.

Important considerations for the constructability schedule review

❑ Weather impact considerations.

- ❖ An important element of the construction planning is to identify seasonal weather periods that could potentially impact the construction work.
- ❖ The **potentially adverse** weather time frames, when it is either too hot or too cold to work, should be **included** in the construction planning and incorporated into the schedule.
- ❖ Historic weather information is readily **available** and should be **consulted** when developing the construction schedule.
  - ✓ *For example the National Oceanic and Atmospheric Administration (NOAA) web site maintains a historic weather database for all regions of the United States.*

Important considerations for the constructability schedule review

❑ Weather impact considerations.

- ❖ Consider using the **scheduling software calendar features** to factor in the potential adverse weather seasons.
- ❖ Construction schedule work activities that are susceptible to these weather impacts, particularly **critical path activities** should be assigned to that weather calendar.
- ❖ The **completion** of **"facility enclosure"** should occur **prior to** the inclement weather season in order to

  allow **interior work to proceed without** unnecessary delay or damage to the interior work.

Important considerations for the constructability schedule review

❑ Weather impact considerations.

- ❖ It is important to consider both **maximum and minimum temperature** requirements for material installation.
- ❖ **Proper sequencing** for the completion of **climate control systems** to provide **temporary (or permanent) heating/cooling** for the **installation of climate sensitive materials** such as sheetrock, millwork, and flooring.

Important considerations for the constructability schedule review

- **Appropriateness of detail.**
  - The construction schedule should **not be a duplication** of the project submittal register, expediting log, or the project completion punch list.
    - ✓ Those are **separate project management documents**.

Recommended Practice

(Site Planning Development)

Work restrictions

- Site access and work restrictions need to be an **element of the SCR**.

- Work restrictions includes items such as
  - Allowable hours for construction noises;
  - Seasonal periods of non-work;
  - Labor or contract restrictions related to work on weekends or holidays;
  - Etc.

- There are **several other elements** related to the development of the site plan and specific site conditions that should be considered in the project planning.

Specialists

- **Specialists** involved in the project need to be **included in the planning** for
  - Cranes;
  - Fire protection;
  - Safety;
  - Material management (procurement, transportation, delivery, and storage); and
  - Others.

Site plan

- The site plan must include **required spaces** for
  1. Temporary facilities and material/equipment laydown areas and
  2. Existing plant structures and features.

- The laydown areas should be located to allow the **most direct access route possible** to the final equipment locations and
  avoid multiple turns along the route.

- The site arrangement plan **must be finalized early** and
  should **not be changed** without valid reason.

Important factors to consider in any schedule constructability assessment

Important factors to consider in any schedule constructability assessment

- **Temporary construction.**
  - Establish a list and locations for the placement of **required temporary facilities** including:
    - ✓ Offices,
    - ✓ warehouse(s),
    - ✓ Laydown areas,
    - ✓ parking,
    - ✓ tool cribs,
    - ✓ fabrication shops (plan to locate adjacent to storage areas),
    - ✓ Medical facility & staff,
    - ✓ Welders' testing facility,
    - ✓ Chemical product storage,
    - ✓ Hazardous waste and combustible storage,
    - ✓ Etc.

Important factors to consider in any schedule constructability assessment

- **Temporary construction.**
  - **Layout** the roads, access ways, fabrication shops and storage to **avoid** the cross flow of materials and minimize traffic interference.
  - Consider **outfitting** **"prepackaged" fabrication shops** in large storage containers or trailers.
    - ✓ These shops completely loaded with tools, equipment, and consumable supplies and could be **readily moved** to the work location and set on concrete work slabs.

Important factors to consider in any schedule constructability assessment

- **Temporary construction.**
  - **When practical**, position the temporary facilities to **take advantage** of natural drainage patterns.
  - The **planning** should also include **removal of**

    the **temporary facilities** at, or **near the end** of, the project construction phase

    to allow for **any remaining construction work** (grading, landscaping, paving, curbs, etc.) that may be required.

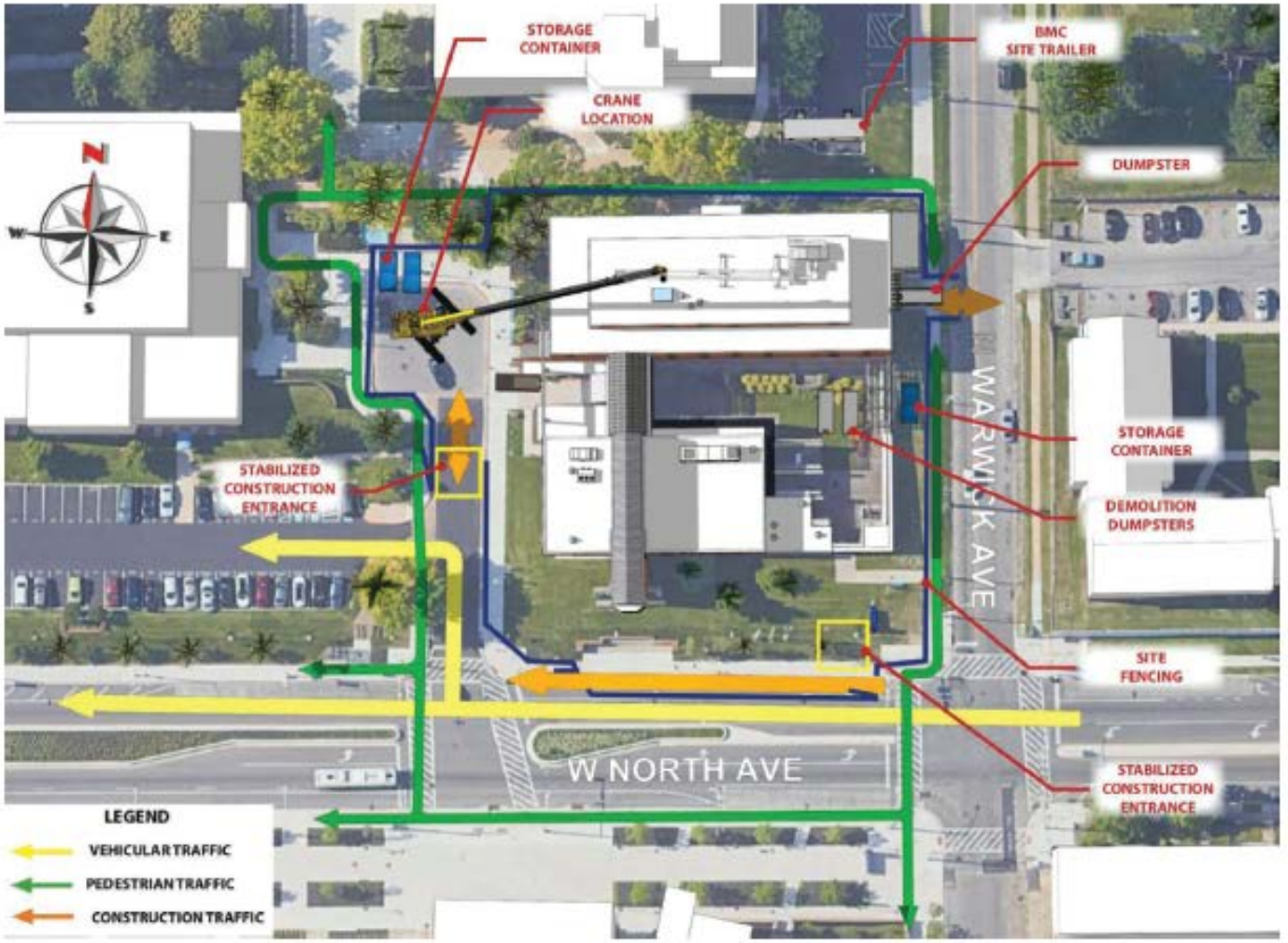
Important factors to consider in any schedule constructability assessment

- **Site access planning.**
  - Site access planning can result in **significant savings** of both labor cost and time.
  - **Location** of the main gate should be **centered** on the construction work to **minimize lost time** due to travel.
  - Depending on **labor contract agreements** (union and non-union) the project may be required to have separate craft entry gates and parking areas.
  - **Maximize open spaces** for work areas, turnarounds, and maintenance.
  - The width of roads and gates must be sized to accommodate the **largest cranes and equipment** that will be used or placed on the project.

Important factors to consider in any schedule constructability assessment

- **Site access planning.**
  - **Staging areas** should be established for items that are to be **preassembled** at the site **before erection**.
    - ✓ These **ground level preassembly** construction activities increase productivity and enhance safety.
  - Consider the use of **man lifts** in lieu of scaffolding where practical as **scaffolding systems** can be time consuming and expensive to erect and maintain.
  - A **daily review** of site access is required as the **site can change daily** as the installation work progresses.

Important factors to consider in any schedule constructability assessment



Example jobsite layout plan

Important factors to consider in any schedule constructability assessment

- **Site plan.**
  - The site arrangement plan should be **reviewed** along with the scheduled construction sequencing to be sure that

    the **planned haul routes** for **heavy equipment** are not closed because of height, width, length, and weight **previously installed facilities/features** or other restrictions.
  - There should be a contingency plan for **late delivery** of large equipment

    so that **other work** can **proceed**.
  - **Review the site plan** for equipment and material deliveries to avoid double handling by setting the **items directly into position** when received.
  - As previously mentioned preassembly and modularization should be incorporated into the construction schedule as **much as practical** for the project.

Important factors to consider in any schedule constructability assessment

- **Staffing and manpower planning.**
  - A review of the **manpower loading and craft staffing levels** is an important element of the SCR.
  - Consider the field craft manpower requirements in relation to the schedule and **prioritize** the **engineering sequence** of design releases to improve leveling of **critical labor peaks**.
  - The **required craft skills** for the **various phases** of the project need to be compared with the local craft labor availability during the planned construction phase.
  - **Other projects in the area** that might compete for craft resources also need to be considered.

Important factors to consider in any schedule constructability assessment

❑ Optimum sequencing.

- ❖ The **construction sequence** should be **optimized** so that there are **not** any engineering or procurement **constraints**.
- ❖ In other words, the **project schedule** should be construction driven and the **engineering and procurement activities** should support that construction schedule.
- ❖ Forecasted procurement durations for material/equipment deliveries must be **evaluated and adjusted** to **support** the construction timing and sequence requirements.
- ❖ **Work** that is not restricted by engineering or procurement **lead-time** should be pushed ahead quickly by construction.

Important factors to consider in any schedule constructability assessment

- **Site safety.**
  - **Site safety planning** includes providing clear access routes to
    1. Prevent **congestion**
    2. As well as **good escape or evacuation routes** in case of fire or other emergencies on site.
  - **Minimize "hot work" permit areas** and establish construction buffer areas **away** from existing operating facilities to **reduce potential accidents** involving facility operations personal who normally should not to be in the construction work areas.

Hot Work Permits are needed for each building where Hot Work will be performed (utility tunnels are considered to be separate buildings). For example, if **one contractor** is performing work at **several different buildings** for one project, a **permit is necessary** for each building.

Important factors to consider in any schedule constructability assessment

❑ Civil work sequencing.

- ❖ The **construction schedule** should maximize the **completion of underground work** as early as practical on the project.
- ❖ Storm drains and sewage drain systems should be **completed early.**
- ❖ Temporary ditching and standby pumping units to **remove surface water** quickly should be including in the **construction planning** when appropriate.
- ❖ If possible the permanent plant sewage treatment facility should be **completed early** and placed into operation to **minimize the need** for temporary facilities.
- ❖ Drainage during **construction excavation** should be **directed away** from equipment foundations.
- ❖ It may be beneficial to complete **parking areas early** to
  1. Reduce dust control requirements and
  2. Provide parking for trades or additional storage for construction materials or equipment.

Important factors to consider in any schedule constructability assessment

- **Permanent systems used during construction.**
  - If **permitted** by the contract specifications, the **permanent plant lighting** should be **completed as early** as practical so that it can be used for night work, shift work, and security.
  - **Use as much** of the permanent systems equipment (transformers, lighting panels, yard lighting) as possible for temporary power requirements.
  - **Temporary power** should be **installed underground** to **reduce exposure** to construction equipment damages.
  - **Layout** overhead temporary power lines along **fence lines** to **minimize interference** with crane booms, and other construction rigging.

Important factors to consider in any schedule constructability assessment

- **Permanent systems used during construction.**
  - **Covered storage** should be provided with a controlled climate for **sensitive electrical** and instrumentation components.
  - Permanent mechanical and piping systems should be used as much as possible for **temporary services** (compressed air, steam, water, etc.).
    - ✓ In summary, **maximize the use** of permanent systems whenever possible or practical.

Recommended Practice
(Schedule Constructability Review Checklist)

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Introduction

- **This SCR checklist** is intended to recommend a process and sequence to **analyze and assess** the construction planning to identify
  - ✓ Potential coordination issues,
  - ✓ Out of sequence work,
  - ✓ Missed work details,
  - ✓ Unrealistic activity durations,
  - ✓ Potential time delays, and
  - ✓ Inter-contractor coordination items.

Work schedule

- The **SCR should** include the construction site and work flow assessment as well as an analysis of the "work schedule" related to:
  - Contractors
  - Limited work hours, restrictions on some construction activities such as blasting, trucking
  - Maintenance of traffic, restrictions on traffic flow and access to site
  - Disruption to public and businesses
  - Coordination with utilities and other agencies
  - Coordination with suppliers (long lead orders)
  - Subcontractors' delays; contractors (ability) to effectively manage subs
  - Weather effects on schedule
  - Cash flow and contractor payments."

Recommended Practice

(Site Construction Schedule Checklist)

Introduction

- A **SCR checklist** should generally follow the **established sequence of construction**.

  A **constructability guide** prepared by Edward D. Wright with Obrien-Kreitzberg Associates Inc. is very good resource that is available on the internet

Schedule assessment

- **Portions of that guide** as related to schedule assessment have been included in the following proposed checklist:

Site access

- **Getting into the site work area:**
  - Construction permits
  - Environmental permits
  - Site clearing & grading requirements: Location of disposal sites for spoils
  - Main entrance gate centrally located
  - Accessibility for construction personnel, equipment, and material delivery
  - One way traffic pattern and parking for craft trades
  - Fences, traffic control, road closures, rerouting of normal traffic
  - Separate routes for construction traffic, vendor deliveries and construction vehicles
  - Utilities: Relocation, Installation of temporary utilities

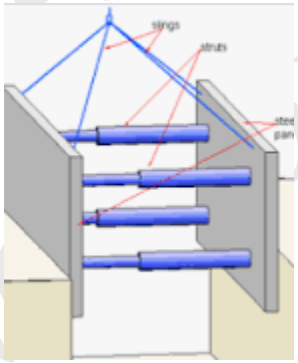
Site access

- **Getting around the site interior work areas:**
  - Accessibility for heavy equipment (crawler canes, etc.)
  - Facilities for construction field offices, client, subcontractors, and medical
  - Temporary power & utilities
  - Weather effects on work areas
  - Sewage & storm drainage system
  - Warehouse(s) & laydown areas
  - Fabrication shops
  - Construction vehicle parking, maintenance and service area
  - Sign and markers

Site civil work

Site civil work

- Clearing & grubbing
- Site excavation & fill (ditches & trenches)
- Storm drainage & sewers
- Duct banks and underground utilities
- Pile driving, shoring, retaining walls
- Grading & paving



A duct bank (or sometimes conduit bank) is a protective system for utility wires to keep them safe underground.

Facility work

Facility work

- Foundations & footings
- Concrete: cast in-place and pre-cast
- Structural framework; windows; exterior siding, cladding, facades; & roof systems
- Building enclosure
- Mechanical & electrical rough-in
- Interior walls & ceiling
- Doors & hardware
- Interior finishes; painting
- Mechanical systems installation, cleaning, pressure testing, & final connection
- Electrical conduit & cable tray loading, pulling cables, wiring connections & testing circuits
- Furniture & fixtures
- System(s) checkout & startup: (i.e. HVAC system balancing, etc.)

Schedule Quality Assurance Procedures

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Introduction

- This section discusses **procedures to rectify** these **common problems** with project schedules, including:
  - **Ensuring** that the schedule accurately **reflects** the complete contractual scope of work,
  - **Evaluating** schedule metrics to assess the **schedule integrity**,
  - **Reviewing** the schedule logic for reasonableness,
  - **Evaluating** the reasonableness and completeness of the **critical path**, and
  - **Comparing** the schedule to the baseline or previous updates to identify **significant changes**.

Important notes

- To **effectively review** a project schedule, the **electronic file** must be made available to the reviewer.
  - **Without access to the native software** file, it is difficult to review and identify potential schedule problems.

1. First, the project schedule should be reviewed to ensure that the complete scope of work is represented in the schedule.
2. Next, **schedule metrics** should be calculated and compared to industry norms.
3. Then, the **schedule logic** should be reviewed in detail to ensure that the logic is reasonable and compete.
4. Lastly, the project schedule critical path should be identified and reviewed in detail.

The findings from each of these examinations can then be **compiled in a report** to serve as a guide for schedule improvement or correction if necessary.

Scope of the project schedule

- To **effectively evaluate** a project schedule to determine if it accurately reflects the project Scope of Work, the reviewer must **understand the project scope**.

- The project contractual Scope of Work is usually identified in **project documents** such as the project contract, drawings, and specifications.

- The **schedule reviewer** should be **familiar** with the industry sector for the project to ensure a **complete work scope review**.

- A **list or work breakdown** of the activities or tasks required to achieve the contractual scope of work should be compiled.

Scope of the project schedule

- By way of example, an EPC schedule for a process plant project may include activities for each of the following tasks:

A. Engineering

- Process Design, Plant Layout and Detailed Design
  - Discipline-Specific Activities
  - HAZOP and Design Reviews
  - Modules
  - EPC Contractor Interfaces

Hazard and Operability (HAZOP) is a systematic approach to determining potential problems that may be uncovered by reviewing the safety of designs and revisiting existing processes and operations in chemical, pharmaceutical, oil and gas, and nuclear industries.

B. Procurement

- Component Procurement
  - Equipment
  - Bulk Materials
  - Factory Acceptance Testing and Qualification
  - Transportation
- Pipe and Module Fabrication and Assembly
  - Fabrication and Assembly
  - Testing and Qualification
  - Transportation

Scope of the project schedule

- By way of example, an EPC schedule for a process plant project may include activities for each of the following tasks:

C. Construction

- Site Preparation and Temporary Facilities
  - Earthmoving/Soil Preparation
  - Laydown Area Preparation
  - Storage Area/Warehousing/Tool Room Construction
  - Waste Disposal Construction
  - Security Construction
  - Temporary Office/Support Base and Services Construction
- Construction
  - Process Units
  - Utilities
  - Piperacks
  - Main Control Rooms, Administration, Workshop Buildings, and Shelters
  - Main/Backup Power Supply and Substations
  - Wharf
  - Tank Farm
  - Other Plant Systems
- System Completion and Turnover
  - Safety Systems
  - Main Control Room Systems
  - Electrical & Instrumentation Systems
  - Mechanical Systems
  - Plant Utility Systems
  - Other Plant Systems
  - Plant Optimization and Tuning

Scope of the project schedule

- By way of example, an EPC schedule for a process plant project may include activities for each of the following tasks:

D. Pre-Commissioning and Start-up

- System Testing and Qualification
- Safety Systems
- Main Control Room Systems
- Electrical & Instrumentation Systems
- Mechanical Systems
- Plant Utility Systems
- Other Plant Systems

E. QA/QC

- Owner Approvals
- Engineering Model Reviews
- Safety Reviews (HAZOP)
- Equipment Inspection and Factory Acceptance Tests
- Pipe Fabrication and Module Shop Inspections
- On-site Construction Inspections
- Testing and Qualification Reviews

Scope of the project schedule

- To review the project schedule scope of work, the project **schedule activities** can be **exported** from the schedule to a database or spreadsheet.

- **Individual schedule activities** generally have a multitude of data or activity codes associated with the activity.

- The **activity description**, along with the **activity codes** should be reviewed and **each schedule activity** can then be categorized against the **work breakdown list.**

Schedule metrics comparison

- This table should at a minimum contain the following activity data for each activity:

- Activity ID
- Activity Description
- Activity Duration Information
  - Original Duration
  - Remaining Duration
  - Actual Duration
- Activity Type
- Activity Status
- Activity Percent Complete
- Activity Dates
  - Early Start
  - Early Finish
  - Late Start
  - Late Finish
- Activity Float
  - Total Float
  - Free Float
- Activity Constraints
  - Early Constraints
  - Late Constraints
- Activity Resources
- Activity Codes
  - Phase
  - Location
  - Responsibility
  - Discipline

Schedule metrics comparison

- **This table** can then be reviewed and analyzed to generate various **schedule metrics**.

- A **listing of several of these schedule metrics** along with an explanation of the procedure used to compile each metric from the activity data follows below.

Schedule metrics comparison

1. ACTIVITY TYPE SUMMARY

- Proper evaluation of project schedule metrics requires knowing **what type of schedule activities** are being reviewed, compiled, and tabulated.
- Schedules generally have a mix of
  - Task activities,
  - Start and finish milestones, and
  - Hammock activities.

  *This metric sums the **total number** of Task, Milestone, and Hammock activities.*
- Hammock activities are generally not used in the calculation of other schedule metrics.

  *In fact, **most schedule metrics** are calculated using only the Task type of activity.*

Schedule metrics comparison

2. ACTIVITY STATUS SUMMARY

- Various schedule metrics calculations are made on groups of activities depending on the **status of the individual activity**.

This metric sums the total number of

1. Complete,
2. In-progress, and
3. Not-started activities.

Schedule metrics comparison

3. NUMBER OF ACTIVITIES PER US $1MM OF COST

- This metric is a calculation of the total number of Task activities in the schedule **divided by** the project cost in millions of dollars.

The metric can be compared to

***similar sized projects** as a measure of the **level of activity detail**.*

Schedule metrics comparison

4. NUMBER OF ACTIVITIES PER MONTH CYCLE TIME

- To compile this metric, the **span of the schedule** is documented from the start of the first task activity to the completion of the last task activity.
- Analysis of this metric involves **totaling the number of task activities** in progress during **each month** of the project, based on actual and early activity dates.
- This information can **then be grouped** by project phase or other pertinent factors, reviewed, and presented graphically to reveal if the **activity detail** is balanced over the course of the project.

*Sometimes projects have a tendency to be **more detailed in the beginning**, then **more general and less detailed** in the **later stages** of the project.*

Schedule metrics comparison

5. AVERAGE ACTIVITY REMAINING DURATION (DAYS)

- The average activity remaining duration metric **excludes completed work**.

- The **remaining durations for all tasks** is summed and

  divided by the total number of task activities that are

  1. In-progress or
  2. Not started.

Schedule metrics comparison

6. EXCESSIVE ACTIVITY DURATION CHECK

- The **activity table** should be reviewed for activities with excessively long planned durations.
- The logic for these activities should be investigated and an evaluation made as to whether these **long duration activities** should be broken down into several shorter duration activities.
- New relationships between the shorter duration activities and other activities in the schedule **may be required**.

Schedule metrics comparison

7. NUMBER OF ACTIVITY CALENDARS

- The schedule calendar definitions are reviewed and then the activity table is evaluated to **identify which calendar** is applicable to each activity.
- **Evaluations are made** of the calendar usage as to whether the **calendar assignment is reasonable** based on
  1. **Where** each task is **preformed** and
  2. **Which** project **resource** or resources are **assigned** to complete the work.

Schedule metrics comparison

8. ACTIVITY CODE ASSIGNMENT CHECK

- The **activity table** is reviewed for information relating to the **activity codes**.
- The activity codes are used to **organize and sort** the individual activities in the schedule.
- A review of the utilization of activity codes allows for an assessment of whether or not
  1. Coding is used consistently and
  2. Is of sufficient detail to **properly sort and organize** the schedule for reviews and reporting requirements.

Schedule metrics comparison

9. NUMBER OF CONSTRAINED ACTIVITIES

- The **activity table** should be reviewed for information relating to activity date and float constraints that

  can **affect the forecasting ability** of the schedule.

- **Activities** are identified that have constraints and the type of constraints.
- This **information** is tabulated and analyzed.

  *The **improper use of constraints** may affect total float values and*

  ***potentially distort** the critical path of the Project.*

  *Constraints can also **control which activities** are impacted by delays or changes.*

- **Mandatory** start or finish constraints prevent the schedule from **responding to** changes or delays.
- The reasoning for the use of these constraints should be explored

Schedule metrics comparison

10. AVERAGE ACTIVITY FLOAT (DAYS)

- The average activity float duration metric excludes completed work.

*The **total float** for **non-hammock activities** remaining to be complete is **summed**.*

- **This value** is the divided by the number of remaining non-hammock activities, yielding an **average total float value**.

- A **high average float value** can indicate that
  1. The project is **not sufficiently detailed** or
  2. **Not** sufficiently **tied** together **logically**.

Schedule metrics comparison

11. FLOAT RATIO

- The calculation of this metrics **uses** the **previously calculated metrics** of
  1. Average activity float and
  2. Average activity remaining duration
- The float ratio is simply the **average activity float** divided by average **activity remaining duration.**
- A **high float ratio** can indicate
  1. Excessive available float or
  2. Insufficient logic in the schedule.

Schedule metrics comparison

12. RESOURCE LOADING

- The project schedule is reviewed to determine **whether activities** have been **resource loaded.**
- If resources have been used in the schedule, there are a **number of metrics** that can be calculated and reviewed.
- For example, the reviewer can **tabulate** the different Resource Types and Resource categories.
  1. Which activities have resources and what type of resources?
  2. Has resource leveling been utilized in the schedule?

Schedule metrics comparison

13. METRICS FOR IN-PROGRESS SCHEDULES

- If the project schedule reviewed is a status update, there are **additional metrics** that can be calculated to reveal potential problems.
- **Two of these metrics** are described below.

Schedule metrics comparison

13.1 PLANNED DURATION VS. ACTUAL DURATION CHECK

- This metric reviews completed task activities.
- The calculation of the average activity actual duration **divided** by the average activity planned duration may indicate a **trend** regarding the forecasting accuracy of the schedule.
- A review of **how many of the completed activities** in an **area or phase** of the project can **reveal problems** that should be investigated.

Schedule metrics comparison

13.2 PERCENT COMPLETE V. REMAINING DURATION ANALYSIS

- This metric reviews in-progress task activities.
- The percent complete versus remaining duration check is used to identify activities that may show incorrect progress reporting.
- Typically, the **percent complete value** is linked arithmetically to the remaining duration value, where:

$$Percent\ Complete = (OD - RD) / OD \times 100$$

- A review of these values in the **activity table** will **identify activities** where the percent complete or the remaining duration is **not consistent with this calculation**.

Schedule logic review

- The first step in a **schedule logic review** is to export the activity relationships to a **database or spreadsheet**.
- The table of activity relationships should include
  1. Predecessor and successor activity ID,
  2. Activity description,
  3. Type of logic relationship, and
  4. Lag value.
- In addition to these minimum requirements, **activity information** from the activity table can be correlated by using the Activity ID as a common element.
- Information relating to activity status and activity codes indicating the **project phase or area** can be applied to

  both the predecessor and the successor activities.

This step can help assess whether activity relationships spanning from one phase to another phase are treated consistently.

Schedule logic review

- The schedule logic review should **utilize information** from both
  1. Activity data table and
  2. Activity logic table

  to assess the **reasonableness** and **completeness** of the schedule logic.

- A fragnet of a changed event can be inserted in the network along the **early part of the critical path** and

  the **schedule recalculated** to **test whether or not**
  1. Schedule completion date and
  2. Other contractual milestones

  are **properly updated**.

Schedule logic review

14. OPEN ENDS

- **Each activity** is reviewed to identify if **it has at least one** predecessor and one successor.
- Activities that do not have at least one predecessor and/or one successor are **identified** and the activity is reviewed to determine

  if the open end may adversely affect the schedule calculations for forecasting dates and activity float.
- A listing should be provided of all activities that are missing predecessor or successor logic other than Project Start and completion milestones.

Schedule logic review

15. PERCENT OF ACTIVITIES WITH NETWORK TIES

- This metric involves the review of **logic ties** for milestones as well as task activities.
- Activities with missing predecessor logic and/or missing successor logic are identified and tabulated.
- The number of activities with missing logic is **subtracted** from the total number of activities resulting in

  the number of activities with logic or network ties,

  this value is in turn **divided by** the total number of activities to

  generate a percentage of activities with network ties.

Schedule logic review

16. EXCESSIVE LAG CHECK

- The **activity logic table** should be reviewed and activities with large lag values **identified**.
- Activities with large lag values should be reviewed and a **determination made if** the large lag values can be replaced with an activity.
- If activities have **negative lag values**,

  the **predecessor and successor** should be reviewed to **determine whether breaking either activity** into smaller activities would **better serve** the intended relationship.

Schedule logic review

17. EXCESSIVE FLOAT CHECK

- The **activity table** should be reviewed for activities with excessively large float values.
- The logic for these activities should be investigated and an **evaluation made as to** whether
  1. Additional logic is required for these activities to **accurately reflect** the project plan or
  2. If dependencies exist that are **not reflected** in the schedule logic.

Schedule logic review

- **ACTIVITY PROGRESS ERRATA**
- The **activity table** should be reviewed to determine if any activities have **progress reporting errata.**

- The recommended checks to perform fall into the following categories:
  1. Activities with **actual dates after** the schedule data date
  2. Activities with an **actual finish date** that are not recorded as 100% complete
  3. Activities with progress measured as percent complete greater than zero, but without an actual start date
  4. Activities **progressed as 100% complete** but with no actual finish date

Critical path evaluation

- The schedule reviewer should review the **reasonableness** and **completeness** of the critical path for the engineering, procurement, construction, and pre-commissioning activities, and any available near critical path activity chains.
- Where potential **vulnerabilities to the critical path** are identified, recommendations to mitigate the delays should be made.
- The reviewer should determine if there is any **evidence that** preferential logic was utilized to **force the critical path**.
- In addition, the reviewer should determine if **activity durations** are consistent when **compared to similar activities**.

Critical path evaluation

- The schedule reviewer should evaluate near-critical paths and

  identify activities that are **likely to impact** contractual milestones and the project completion date,

  but have **not been identified** as being on the critical path.

- These identified activities should be placed on a watch list for evaluation on **future schedule updates.**

Project schedule update comparisons

- The list of changes to the schedule, individual activities, and logic relationships that should be investigated include the following:
  - Added and Deleted Activities
  - Activity Start and Finish Delays
  - Activity Duration Changes
  - Changes to the Critical/Near Critical Paths
  - Significant Changes to the Schedule Logic
  - Added or Changed Constraints
  - Changes in Schedule Calculation mode
  - Changed Activity Coding
  - Added or Changed Resources
  - Added Schedule Log Entries

Schedule Quality and Deficiency Check Examples

Introduction

- Deficiencies or errors in the schedule, if not corrected, could substantially affect the accuracy of forecasted critical and near-critical paths.
- Therefore, schedule quality checks should be considered a requirement when assessing the critical and near-critical paths.
- **Table 1 lists** some common quality and deficiency checks to consider.

Example

Item No.	Quality/Deficiency Check	Description
1	Missing Work Scope	Review contract documents and work scope estimates to verify to the extent possible that the schedule file represents all required contract scope. Commonly missed work scope activities include the submittal process, owner or contractor approvals, customs clearance, quality assurance and control, concrete cure periods, pre-commissioning steps, punchlist requirements, and the turnover process. Correcting the schedule file for missing work scope activities could change forecasted dates and potentially alter the critical and near-critical paths.
2	Excessive Number of Open-End Activities	Open-end activities are defined as having no predecessor activity, no successor activity, or both. Good scheduling practice requires a minimal number of open-end activities except for: (1) the project start activity (no predecessor activity); and (2) the project completion activity (no successor activity). A large number of open-end activities can create erroneous float values and cause forecasted activity sequences to be performed illogically (*i.e.*, excessive float from the data date to project finish). Correcting open-end activities can change float values that may affect the forecasted dates for critical and near-critical activities.

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Example

3	Large Number of High-Float Activities	A large number of high-float activities in a project schedule may indicate underlying schedule quality problems. Schedule paths with high float values typically result from open-end activities discussed in Item 2 above, artificially constrained activities, or lack of workflow optimization on the part of the contractor. Schedules with many high-float activities should be thoroughly examined and corrected for any open ends or missing logic links to better optimize forecasted dates and float values.
4	Inconsistent Use of Schedule Calculation Modes	Retained logic is the default calculation mode for nearly all scheduling software programs. Another scheduling calculation mode is progress override, which allows out-of-sequence work activities to progress without delay, regardless of whether or not logical predecessors are complete. Progress override is based on the premise that a contractor has all the labor, equipment, and supervision resources required to work in multiple areas concurrently. Many contractors use progress override to update a schedule without having to spend time correcting out-of-sequence work. In some cases, contractors switch schedule calculation modes during the project from retained logic to progress override and then back to retained logic without reason. Inconsistent use of schedule calculation modes can create problems. Switching to a consistent mode may change the critical and near-critical paths.

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Example

5	Overuse of Constraints	The number of constraints applied to activities should be checked. Constraints are restrictions imposed on either the start or finish of an activity that may artificially lock down schedule activity dates and prevent them from naturally "flowing" during forward and backward pass calculations to determine activity float values and the critical path. While contractual requirements may necessitate some constraints, the overuse of constraints could cause discontinuities in the critical and near-critical paths between the data date and the final completion activity, thereby masking the true critical path. Fixing problems caused by overuse of constraints could alter the critical and near-critical paths.
6	Misapplication of Calendars	If activities are assigned to the wrong workday calendar, such as a five-day work week rather than a seven-day work week, critical path calculations may be incorrect. Schedule calendar definitions should be reviewed, and then critical and near-critical activities should be evaluated to verify which calendar applies to each activity. Calendar assignments should be evaluated for reasonableness based on where each task is performed and which project resources are assigned.

Conclusion

- If a schedule model contains one or more of the problems identified above, this may **materially impact**, directly or indirectly, the reasonableness of the critical and near-critical paths.
- If **not corrected**, these issues may **compromise important project decisions**, including the application of **limited resources**.
- Correcting the mistakes listed above could involve an **iterative process** requiring time and effort by the project team.

Schedule Quality Assurance Services

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Brochure

International Experts in Claims Analysis, Dispute Resolution, and Project Management for Process, Oil & Gas, Pipeline, Power, Industrial, Infrastructure, and Building Construction Projects

LONG INTERNATIONAL

Schedule Quality Assurance Services

OVERVIEW

Many project schedules are often poorly prepared and require extensive rebaselining during project execution to become a useful project management tool to properly measure progress, determine the effect of changes in scope, and forecast the completion of contractual milestones and overall project completion dates. Poorly prepared schedules do not provide a reliable tool to measure the amount and responsibility for delays that occur during project execution to provide a basis for a time extension or to assess the need for acceleration to mitigate delays. To rectify these common problems with project schedules, Long International provides Schedule Assurance Services.

1. Scope of the Project Schedule

Long International will review the list of schedule activities to determine that the schedule accurately reflects the contractual Scope of Work. Typical scope of work activities for a process plant project include, but are not limited to, the following tasks:

A. Engineering

- Process Design, Plant Layout and Detailed Design
  - Discipline-Specific Activities
  - HAZOP and Design Reviews
  - Modules
  - EPC Contractor Interfaces

B. Procurement

- Component Procurement
  - Equipment
  - Bulk Materials
  - Shop Testing and Qualification
  - Transportation
- Pipe and Module Fabrication and Assembly
  - Fabrication and Assembly
  - Testing and Qualification
  - Transportation

C. Construction

- Site Preparation
  - Earthmoving/Soil Preparation
  - Laydown Area Preparation
  - Storage Area/Warehousing Construction
  - Waste Disposal Construction
  - Security Construction
  - Temporary Office/Support Base and Services Construction
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D. Pre-Commissioning and Start-up

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- Electrical and Instrumentation Systems
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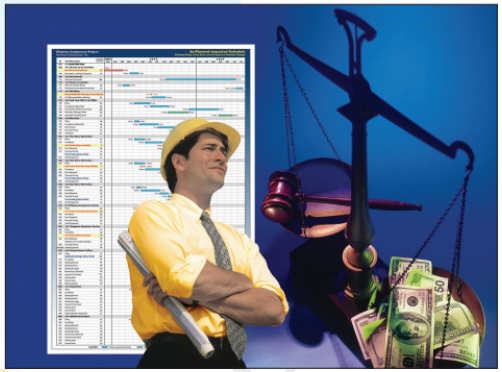
- Plant Utility Systems
- Other Plant Systems

E. QA/QC

- Owner Approvals
- Engineering Model Reviews
- Safety Reviews (HAZOP)
- Equipment Inspection and Factory Acceptance Tests
- Pipe Fabrication and Module Shop Inspections
- On-site Construction Inspections
- Testing and Qualification Reviews

For offshore projects, different scope of work and activity definitions will be included in the project schedule. Activities for the engineering, procurement, fabrication, and assembly of the hull, topsides, risers, subsea mooring, and other work necessary for sailaway, as well as offshore installation, start-up, and commissioning will be evaluated. Based on the contractual requirements for offshore projects, a similar analysis will be prepared to ensure that all contractual scope is included in the project schedule.



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