Scheduling a Project at Different Levels

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Abstract

Scheduling a project at the right level, at the right time, is an important consideration in project planning and scheduling. During management-level planning, when executive and senior management are involved, project-level schedules prevail. Schedules become detailed as the planning horizon switches from the whole of the project to project stages or phases; with assumptions tested and information firmed-up, management can engage in detailed planning.

Practitioners who develop schedules at different levels do not agree on the criteria that apply to summary- and detailed-level schedules, including scheduling technique. This paper reviews recent developments on the concept of *schedule levels*, including the hierarchy in *Guide to the Forensic Scheduling Body of Knowledge Part I* (*FSBOK Guide*). Aspects of the *FSBOK Guide* reviewed include correlation to the work breakdown structure (WBS), schedule granularity, scheduling technique, integration of levels and other criteria. To avoid getting lost in the details, keeping the Level 2 schedule current for the duration of the project and limiting rolling wave planning to Level 4 schedules are advocated.

Background

Jelen discusses separate but coordinated schedules at different levels: "The various participants in a construction contract have different levels of interest in the scheduling of the project. The owner and the contractor's home office are interested in summary level schedules. Project-level personnel are interested in more detail thus there are various schedule levels" [Humphreys, 1991, p 495]. Jelen's position that there is no universal agreement as to the number of schedule levels and their format is evidenced by the following interpretations of a Level 2 schedule and what it entails.

Table 1 Varying Interpretations of Level 2 Schedules in Construction

Treatise	Level 2 Schedule Considerations	Schedule Basis	Scheduling Technique	General Intent
Humphreys [1991, p 496]	Each of the level 1 components is further subdivided…In most cases this schedule level can only be shown in bar chart format, although key constraints may be possible	Developed by dividing level 1 activities into subactivities	Bar chart	Not expressly designated
CII [1987, p 10]	Essentially adopts the Jelen interpretation with the addition "milestones are normally included"	By further detailing the level 1 schedule	Bar chart	Not expressly designated
Wickwire, et al. [2003, p 49]	Detailed master integrated schedule covering all phases of the project and in network format.	Developed independently	Network schedule	Plan, implement and control the overall project
AACEI [2010, p 55]	Activity- and deliverable-centered schedule containing a middle amount of detail in time-scaled network diagrams or bar charts. The status of the detail activities summarizes to the level 1 summary schedule	Developed independently; it summarizes to the level 1 schedule	CPM time-scaled network or bar chart	Integrates engineering, procurement and construction
Plummer-Wooley [2005]	Summary schedule, identifies major activities, interface points and duration estimates	Supports the level 1 schedule	Not prescribed	Show all Level 1 interfaces

Using higher-level schedules as bases for developing detailed schedules is an approach that addresses a practical consideration—as the project develops, the level of detail in the schedule increases. As detail expands, use of the schedule migrates from management planning to performance-level schedule and control. Correlating activities at different schedule levels is effectuated by drawing activity codes from a common hierarchical coding structure.

Approaching the scheduling of the project in coordinated schedules, each schedule at a different level, is progressive elaboration, a concept described in *A Guide to the Project Management Body of Knowledge* (*PMBOK® Guide*):

> Because of the potential for change, the project management plan is iterative and goes through progressive elaboration through the project's life cycle. Progressive elaboration involves continuously improving and detailing a plan as more-detailed and specific information and more accurate estimates become available. Progressive elaboration allows a project management team to manage to a greater level of detail as the project evolves. [Project Management Institute (PMI), 2008, p 7]

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Recent Developments

In 2010, AACE International issued Recommended Practice No. 37R–06 Schedule Levels of Detail—As Applied in Engineering, Procurement and Construction (RP 37) [AACEI, 2010]. RP 37 is a guideline to establish a common frame of reference and understanding when describing the level of detail for any schedule. RP 37 identifies what AACEI considers four generally acceptable methods. Further, RP 37 describes a five-level method based on schedule level requirements, levels of interest and the intended use of each schedule level [AACEI, 2010, p 3].

RP 37 considers Jelen's levels and the CII levels acceptable "numeric schedule levels" [AACEI, 2010, p 2]. RP 37 further describes the engineering, procurement and construction schedule levels method used by many larger EPC organizations (referred to as the *EPC Model*), and a descriptive levels methodology that uses descriptive words in place of numerical levels to identify the desired level of schedule [ACCEI, 2010, pp 4–5].

Stephenson, an RP 37 contributor, describes *schedule classes* that differentiate between high-level schedules (based on limited information) and execution and control schedules, along with *schedule levels* that establish level of detail required for communication and reporting [Stephenson, 2007]. RP 37 prescribes the scheduling technique that may apply to the Stephenson's levels—Level 1 and Level 2 schedules are typically in Gantt format, while Level 3 schedules are typically in Gantt or CPM format and are processed using CPM software. Stephenson's schedule classes form the basis for AACE International Recommended Practice No. 27R-03 Schedule Classification System [AACEI, 2010].

RP 37 does not provide guidance on activity duration ranges for the schedule levels described. When discussing *Schedule Granularity*, Woolf posits, "Most seasoned Execution Schedulers have some *duration range* in the back of their heads that they will quickly recite when asked about level-of-detail. One technique involves the project's length, with the duration range expressed as a percent of project length; say, 1–3 percent" [Woolf, 2007, p 254]. Reportedly, AACE International Recommended Practice No. 32-04 Determining Activity Durations, which is in public review, will include guidance for determining activity durations in response to schedule classes and schedule levels.

Besides AACEI, PMI and the Chartered Institute of Building (CIOB) are engaged in the formulation of scheduling standards. Relative to PMI, neither the *PMBOK Guide* [PMI, 2008] nor *The Practice Standard for Scheduling* [PMI, 2007] provides any guidance on schedule levels. The *CIOB Guide* describes three types of project-level schedules: 1) the development schedule, 2) the tender schedule, and 3) the working schedule, the latter considered as the schedule used for planning and progressing work on-site from commencement to completion [CIOB, 2011, p 19]. The *CIOB Guide* promotes levels of schedule summarization for effective reporting using software roll-up features [CIOB, 2011, p 35], and outlines *five usual* reporting levels for which schedule design should allow at the outset. Once the working schedule is generated, rather than maintaining the earlier, less detailed schedules, varying activity duration ranges based on planning horizon, and roll-ups of the working-level activities to develop Level 1–3 reports, are advocated.

Weaver, a *CIOB Guide* working group member, offers a hierarchy of Level 1–5 schedules, from summary- to detailed-level schedules, that aligns with RP 37 and is augmented to include the party responsible for developing and maintaining each schedule [Mosaic, 2008]. Eleven notes that amplify key criteria are provided. In Note 11, Weaver describes *schedule density*, a concept elaborated by the *CIOB Guide* [CIOB, 2011, pp 30–32, 40, 45]. Density is the *CIOB Guide* approach to progressive elaboration *within the working schedule*, and reflects the following—because in complex projects it is impractical to plan a working schedule in all its detail at the onset, the detail in activity definition (schedule density) decreases downstream from the schedule date. The working schedule "[m]ust be completed in high density for the first three months of the project, before work on site commences" [CIOB, 2011, p 19].

Per the *CIOB Guide*, density within the working schedule may be expected to increase as better and more certain information becomes available. High density is appropriate for activities taking place within three months after the *schedule date*. Medium density is appropriate for activities taking place between three and nine months after the schedule date. Low density is appropriate for activities taking place nine or more months after the schedule date. Low density activities may be several months in duration. Medium density activities are no longer than two months and are focused on one type of work in a specific location. High density activities are resourced, with duration no longer than the schedule update period and with specific workers allocated. Weaver posits that low and medium density would be used for the Level 3 schedule whereas most of a Level 4 schedule would use medium density [Mosaic, 2008, pp 3–4]. This position is a variation on *CIOB Guide* density as it accommodates both schedule level and planning horizon.

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FSBOK Guide Part I Multi-Level Schedule Hierarchy

In 2010, the *FSBOK Guide* introduced a schedule hierarchy for coherent summary-level and detailed-level schedules intended for mega contracts (construction exceeding 42 months) and major contracts (construction spanning 36–42 months), but scalable to other complex contracts [Ponce de Leon et al., 2010, pp 36-37]. The hierarchy advocates network-based schedules for levels 1–4, maintaining a Level 2 in time-scaled network format current for the duration of the project and limiting rolling-wave planning techniques to Level 4 schedules. The *FSBOK Guide* hierarchy is suitable to top-down and roll-up integration of separate network schedules for levels 1–4, and, by way of example, is aligned with the *MasterFormat* approach to construction WBS hierarchies [Construction Specifications Institute (CSI), 2005].

While it is common for the Level 3 schedule to drive the periodic updating process, the *FSBOK Guide* hierarchy assumes that both the Level 1 schedule and Level 2 schedule will be updated periodically as well, and that they will remain current with the Level 3 schedule (and therefore the Level 4 schedules that are active) throughout the project. In Table 2, for Level 2–4 schedules prepared for the project 1) the lower end of duration ranges is intended for activities for which hard logic applies, and 2) the upper limit of duration ranges is intended for activities scoping bulk commodities.

Table 2 Five Levels of Coherent Schedule Documents (Applicable to Construction Mega and Major Contracts)

L	General Intent and Format	Scheduling Objective
1	**Executive Schedule** ▪ Establishes Contractual Milestones (if Included with the Request for Bids) or Demonstrates Conformance to Contractual and Other Milestones (if Included with the Bid and/or the Contract) ▪ Time-Scaled Network Diagram (Commonly One Sheet) ▪ Kept Current with Level 2 ▪ Compares to RP 37 Level 1, Wickwire et al. Level 1 and Mosaic Level 1	Portrays Controlling, Summary-Level Activity(ies) Between Milestones at CSI Division Grouping Level ▪ Key Procurement Scope and Overall Commissioning Sequence Included ▪ Empirical Mega (Major) Construction Activity Duration: 20% to 40% of Contract, Generally 6 to 18 Months (10% to 30% of Contract, Generally 3 to 12 Months)
2	**Management Schedule** ▪ Project Manager Input and Sign-Off ▪ Developed with the Bid or Before Mobilization ▪ Time-scaled Network Diagram ▪ Establishes the Critical Path, Near-Critical Paths and Key Target Dates for the Initial (Rev. 0) Progress Schedule ▪ Conforms to the Construction Plan, Including Constructability, Targeted Means and Methods, Craft Levels and Shared-Resource Dependencies ▪ Mostly Finish-to-Start Logic Ties ▪ Roll-Up (Activities and Logic) of Level 3 Re-Baselining and Updating ▪ Compares to RP 37 Level 2 and Mosaic Level 2	Driving Path for Structures & Major Process Systems at the CSI Division Level (e.g., Earthwork, Foundations, Framing, Enclosure, MEP Services and Process Equipment) ▪ May Subdivide Into Area Grouping or Tier Grouping ▪ Based on Constructability ▪ Normal Adverse Weather-Validated ▪ Long-Lead Equipment & Material Procurements ▪ Critical Commissioning Sequences ▪ Empirical Mega (Major) Construction Activity Duration: 10% to 20% of Contract, Generally 3 to 9 Months (5% to 15% of Contract, Generally 2 to 6 Months)
3	**Progress Schedule** ▪ Site/Construction Manager Input and Sign-Off ▪ Time-scaled Network Diagram or Bar Chart with Logic ▪ ***Drives*** the Updating Process ▪ Integrates Vendor Design, Fab/Delivery, Construction, System Completion and Commissioning ▪ May be Craft Loaded (Typically, Critical Crafts) and Rely on Critical Shared-Resource Dependencies (e.g., Shared Crane) ▪ Activity Cost Loading, if Contractually Required ▪ Compares to RP 37 Level 3, Wickwire et al. Level 2 and Mosaic Level 3	Grouping of CSI Divisions in Areas or Elevations for Structures and Major Process Systems ▪ Level 2 Earthwork, Foundation, Framing, Enclosure, etc. Subdivided into Component Chunks ▪ Normal Adverse Weather-Validated ▪ Detailed Delivery Sequences ▪ Integrated, Detailed Commissioning Sequence ▪ Formula Mega (Major) Construction Activity Duration: 2% to 5% of Contract, Generally 3 to 12 Weeks (1% to 3% of Contract, Generally 2 to 6 Weeks)
4	**Working Schedules** ▪ Supervision Input and Sign-Off▪ Developed Before Starting a Phase or Area ▪ Often Separate Schedules ▪ Time-scaled Network Diagrams or Bar Charts with Logic ▪ Coordinated with Field Supervision (Contractor) and Subcontractor Input ▪ Trade Coordination ▪ May be Craft Loaded and Detail Crew Movements and Other Means & Methods ▪ May be Done on a Rolling Wave Basis (e.g., Every 3 Months) ▪ Compares to RP 37 Level 4, Wickwire et al. Level 3 and Mosaic Level 4	Groups CSI Sections Within Elevation or Area for Structure or Process System ▪ Level 3 Earthwork, Foundation, Framing, Enclosure, MEP, etc. Subdivided into Fragnets, Activities Biased Towards Subcontractor or Trade ▪ Normal Adverse Weather-Validated ▪ Detailed-Level Procurement and Commissioning Activities▪ Formula Mega (Major) Construction Activity Duration: 1% to 3% of Contract, Generally 2 to 6 Weeks (1% to 2% of Contract, Generally 2 to 4 Weeks)
5	**Look-Ahead Schedules** ▪ Subdivide Progress and Upcoming Level 3 or Level 4 Activities into Tasks for the Next 2 to 3 Weeks ▪ Developed by Crew Foreman Typically in Bar Charts or Similar Format ▪ Tasks are Crew Loaded ▪ Reviewed in Site Progress Meetings ▪ Compares to RP 37 Level 5 and Mosaic Level 5	Work Assigned to Crews ▪ Broken Down by Specific Components, Based on Verification That Work Can Proceed and That Materials, Design Documentation and Other Installation Information Are Packaged and Made Available to Crew Foremen ▪ Task Duration: From a Few Days to Three Weeks

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The *FSBOK Guide* multi-level schedule hierarchy addresses the correlation between the construction WBS and each schedule level. For instance, Level 2 activities are intended to portray driving paths for structures and major process systems at, for example, CSI division level (e.g., earthwork, foundations, framing, enclosure, MEP services & process equipment), and may use area or tier grouping for mega project schedules. Normally, a Level 2 schedule portrays a limited number of activities for a WBS package identifying, for example, *'Building Foundations.'* Once the design is released for construction, means and methods are chosen (e.g., whether to start at the east or west end of the building), and the WBS is thus detailed, it becomes practical to develop a Level 3 schedule of increasing detail and, eventually, a Level 4 schedule dividing the WBS foundations package into form, rebar/embed, placement and curing activities and logic as dictated by supervision's approach to performing the foundations work.

The *FSBOK Guide* approach to correlating schedule level with WBS definition supports the *PMBOK* concept of *rolling wave planning* [PMI, 2008, p 135] *for Level 4 schedules*. With the Level 2 schedule typically developed before mobilization, uniform activity duration ranges (e.g., 6 to 18 months) for the whole of the schedule are the norm. With good practice requiring that the Level 3 schedule be based on the Level 2 schedule, subject to detailed information gained in the interim, uniform activity duration ranges (e.g., 3 to 12 weeks) for the whole of the schedule are the norm.

With the WBS as the framework that identifies project work deliverables and components, if lower-level schedules are developed from higher-level schedules, it becomes imperative to correlate WBS levels of indenture and schedule hierarchy. This requires a coding structure that allows for horizontal and vertical integration [Plummer-Wooley, 2005, p 6]. PMI advocates: "The activity list, WBS, and WBS dictionary can be developed either sequentially or concurrently, with the WBS and WBS dictionary as the basis for development of the final activity list. Each work package within the WBS is decomposed into the activities required to produce the work package deliverables" [PMI, 2008, p 134].

The *FSBOK Guide* hierarchy advocates network-based level 1–4 schedules. In the absence of contrary contractual language, Level 3 and Level 2 schedules are appropriate documents to evaluate timely performance, delay and disruption and time extension requests—whether when such issues arise or where the evaluation is undertaken *post-completion.* In the *FSBOK Guide* scheme of thought (within the context of mega and major contracts), the following considerations apply to the corresponding efficacy of level 1–4 schedules in forensic schedule analysis:

- A Level 2 schedule in a time-scaled network format that portrays the contractor's plan at contract award at an appropriate granularity and that remains current and in conformance to the contract is a relevant and reliable forecasting tool, provided it establishes the critical path(s) and near-critical paths based on contract dates, the construction plan, normal adverse weather and key deliveries. For this very reason, it is likely to be a relevant and reliable source document for the forensic network model.
- Depending on the schedule analysis method used, a Level 3 schedule may be overly detailed as a source document for the forensic network model, particularly where not relevant to the facts of the case. Forensic analysis using a Level 3 schedule may divert attention to non-issues and detract from the issues in dispute without gaining analysis accuracy. Where this compromises analysis accuracy, an acceptable protocol is to generate a reliable summarization of the Level 3 schedule [AACEI, 2009; Keane & Caletka, 2008].
- The subdivisions of Level 3 schedule activities existing in a Level 4 schedule are often suitable bases for conducting time impact analysis at the fragnet level [Ponce de Leon et al., 2010, pp 61–63].
- A Level 1 schedule in a time-scaled network format that is coherent with the Level 2 schedule is a valid source document for a forensic schedule analysis demonstrative, provided it portrays controlling summary activities between milestones at the CSI Division Grouping Level or equivalent indenture in another WBS scheme, including critical procurement activities, commissioning activities and, possibly, schedule reserve.

The *FSBOK Guide* recognizes that, while the notion of Level 1, Level 2 and Level 4 *bar chart* schedules may be acceptable in some quarters for prospective planning and scheduling (contemporaneous with the work), use of bar charts for forensic schedule analysis is discouraged as bar chart schedules sans logic and that do not identify the critical path ***will not meet*** technical schedule analysis standards. Use of CPM scheduling techniques in forensic schedule analysis has been recognized by the US legal system since the 1970s [Wickwire & Smith, 1974, p 1061], and remains the standard to this day: "CPM scheduling has been used by the construction industry forensically and analytically to prove cause, effect and liability in delay claim prosecution and dispute resolution" [Lifschitz et al., 2009, p 15].

Where separate *rolling wave* Level 4 schedules are generated, it is practical to design Level 2 and Level 3 schedules with uniform density. The term *activity or schedule granularity* is used when activity duration range is uniform for the duration of each schedule, appropriate to its level in the hierarchy. "[A]s to activity duration range aka activity granularity, it is good practice to avoid activity durations incongruent with the schedule level—either too long or too short for the intended use of the schedule. Granularity is finer (shorter duration) as better and more certain information becomes available, coinciding with criteria applicable to schedule levels" [Ponce de Leon et al., 2010, p 36]. Table 3 contrasts granularity (uniform range for each level of schedule) and density (different ranges within a schedule).

Table 3 *FSBOK Guide* Schedule Granularity (Mega Contracts) vs.*CIOB Guide* Schedule Density (Complex Projects)

L	Granularity	Duration Range	L	Density	Activity Duration
1	Coarse	6 to 18 Months	1	Low	Exceeding 2 Months
2	Low	3 to 9 Months	2	Low	Exceeding 2 Months
3	Medium	3 to 12 Weeks	3	Medium	Less Than 2 Months
4	High	2 to 6 Weeks	4	Medium	Less Than 2 Months
5	Fine	Days to 3 Weeks	5	High	Under Update Cycle

Holding schedule granularity uniform vs. increasing density of downstream activities as the data date progresses avoids an ever-growing activity count. When the schedule multiplies in number of activities, its usefulness as a relevant, reliable forecasting tool is degraded. This is due perhaps to the extent of schedule machinations that the scheduler may have engaged in to attain realistic dates and critical paths, and surely because it fundamentally trends toward a highly-disordered schedule. Table 4 provides a synopsis of the *FSBOK Guide* hierarchy.

Table 4 *FSBOK Guide* View of Level 1–5 Schedules (Mega & Major Contracts)

L	General Intent	End User	Schedule Objective	Resourced	Life Cycle	Schedule Granularity
1	Graphical snapshot of driving summary activities and logic	Executives and senior managers	Demonstrate conformance to contract and key milestones	Cash flow	Entire duration	Generally 6 to 18 months
2	To establish driving critical path and near-critical paths to contract and key milestones	Senior managers including the project manager	Used to show compliance with responsibility for on-time performance and completion	Cash flow; key shared resource	Entire duration	Generally 3 to 9 months
3	Detail needed for construction management, staging deliveries and project control	Construction manager and scheduling staff	Used to execute, progress, monitor and control the work	Critical craft; key shared resource	Entire duration	Generally 3 weeks to 3 months
4	Working schedule that supports Level 3 sequences	Area supervision	Integrated schedule for an area or the next 3 months	Craft loaded	Phase or area	Generally 2 to 6 weeks
5	Look-ahead schedule	Crew foremen and supervision	Crewing based on validation that work can proceed	Crew loaded	2 to 3 weeks	Days to 3 weeks

Summary and Conclusions

The time has come to bid farewell to bar chart techniques for Level 1, 2 and 4 schedules. This will not only promote more coherent planning, but will allow all contemporaneous schedules to play a role in forensic modeling.

An alternative to working with Level 3 schedules that become massive as schedule density increases is to approach the scheduling of a project in a multi-level schedule sequence that involves deriving a lower-level schedule from the next higher-level schedule, while limiting reliance on rolling wave planning techniques to the network-based Level 4 schedules. For any schedule in the hierarchy, maintaining granularity uniform, from beginning to end, better ensures a highly-ordered network of realistic dates and reasonable floats, *ergo* a relevant and reliable forecasting document.

In the *FSBOK Guide* scheme of thought, the activity granularity designed into a Level 2 schedule is likely to yield a relevant and reliable source document for forensic schedule analysis. Because of the activity granularity typically relied upon, a Level 3 schedule may detail paths not relevant to the facts of the case; analyzing non-issues may detract from and confuse the issues in dispute without gaining analysis accuracy. The detail in a Level 3 schedule used in forensic schedule analysis should be made proportionate to the facts at issue by means of reliable summarizations.

While this author favors approaching the scheduling of a project in separate but coherent summary- and detailed-level schedules, each schedule with uniform granularity, the principles discussed are adaptable to approaches that are based on one schedule designed at different levels of detail by varying schedule density based on planning horizon.

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