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SCHEDULE QUALITY, SCHEDULE EVALUATION AND SCHEDULE CONFORMANCE SCORING: QUANTITY SURVEYORS GET READY!

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ABSTRACT: *The paper presents a literature survey of the quality of a good construction schedule. One which conforms to contractual requirements. Contractors frequently develop detailed schedules after or before contract award. They are required to submit these to the building owner or his representatives for assessment and approval. Success of a project depends, among other factors, on the quality of its schedule. The importance of assessing the goodness of schedules, poses the question: How can the schedule be assessed if it is complete and technically sound? What should be the procedure and content of such evaluation? When construction contracts require evaluation of the initial schedules by owners, frequently there are only vague and general clauses indicating the schedule to be in compliance with project scope and to have the appropriate level of detail. Rarely is there any specification indicating how the evaluation should be conducted, its procedure and content. The purpose of this research therefore is to catalogue the procedure and content of such an evaluation in preparing the Quantity Surveyor to perform this role particularly in the traditional procurement method. There are numerous publications describing the process of cost analysis. But very few comparable literature for evaluation of construction schedules is currently available. Only recently, thirty four conceptual provisions were identified from literature to criticize the initial and in-progress schedules of construction projects. This literature search describes two practical methods for evaluating the quality of the construction schedule to ensure that they conform to contractual requirements. These are the computerized system named "CRITEX" introduced for critiquing construction schedules of mid-rise commercial buildings. The Defense Contract Management Agency (DCMA), also developed another method for initial and in-progress schedule evaluation. The paper concludes that just as the Quantity Surveyor does detail tender analysis and tender evaluation before recommending a contractor for award, now that the construction schedule may soon become a contract document in Nigeria, Quantity Surveyors should develop competencies to be able to evaluate the contractor's schedule and recommend appropriate contractor for the award.*

KEYWORDS: Schedule evaluation, Schedule quality, Schedule conformance scoring, Quantity Surveyors

INTRODUCTION

Moosavi and Moselhi, (2012) posits that contractors frequently develop detailed schedules after or before contract award. They submit these schedules to the building owner or his representatives for assessment and approval. The approved schedules will then form the project's schedule baselines subsequently used to manage the project. Management here encompasses tracking, progress reporting as well as administration of construction disputes and claims. Success of a project depends, among other factors, on the quality of its schedule, which can be used to identify probable potential problems, (GAO, 2009). The importance of assessing the goodness of schedules, poses the question, (Russell and Udaipurwala, 2000 in

Moosavi and Moselhi, 2012): How can it be assessed if the schedule is complete and technically sound? What should be the procedure and content of such evaluation? When construction contracts require evaluation of the initial schedules by owners, frequently there are only vague and general clauses indicating the schedule should comply with project scope and have appropriate level of detail. Rarely is there any specification indicating how the evaluation should be conducted, its procedure and content.

There are numerous publications describing the process of cost analysis, (Douglas, 2009 in Moosavi and Moselhi, 2012). But very few comparable literature for evaluating construction schedules is currently available. Only recently, De La Garza, (1988) elicited thirty four conceptual provisions to criticize initial and in-progress schedules of mid-rise building construction. His research introduced a knowledge engineering methodology to transform scheduling knowledge to a specific format for an operational Knowledge Base System (KBS). However his work was not fully automated in a software system. In another study, De La Garza and Ibbs, (1990) introduced a computerized system "CRITEX" for critiquing construction schedules of mid-rise commercial buildings. Dzeng and Lee (2004) developed "Schedule Coach" system, by integrating case-based and rule-based reasoning, for the same purpose. Application of that system was restricted to schedules developed using a single set of standard activities. In similar attempts by the US government, the Defense Contract Management Agency (DCMA) developed a method for initial and in-progress schedule assessment and evaluation. DCMA introduced a 14-point schedule assessment to be performed for a thorough and objective analysis of integrated master schedules, (Berg et al, 2009). The DCMA-14 point assessment focuses mainly on schedule components such as leads, lags, constraints and floats, by posing some metric thresholds. Though these thresholds have been in debate by experts (Winter, 2011). Similar to the DCMA-14 point assessment, the GAO in the US developed a guide named "GAO Schedule Assessment Guide: Best Practice for project schedules, (GAO, 2009). That guide contains nine scheduling best practice, mainly generic and conceptual.

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Moosavi and Moselhi, (2012), presents a framework for effective schedule evaluation of initial detailed construction schedules. Their framework is based on application of critical path method. It includes a software called Schedule Assessment and Evaluation (SAE) software developed to assist owners in evaluation of construction project schedules. A typical assessment report is presented in Figure 8. The SAE performs schedule assessment in three tiers; (1) Assessment of the schedule against industry recommended practice using rules of thumb and benchmarks,

(2) Job logic assessment of selected construction trades and (3) Assessment of productivity and crew size considering a number of commonly used trades in building construction. A case example is analyzed to demonstrate the use of the developed software for evaluation of goodness of schedules. Initial development work on the proposed method began by conducting a comprehensive literature review to extract the characteristics of good schedules. This effort included input and review from three sources; (1) journal articles, conference papers and dissertations, (2) textbooks, (3) recommended practices and guidelines prepared by government agencies and professional organizations. In essence a check list was developed based on integration of scattered knowledge on the domain area of schedule quality. Moosavi

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and Moselhi's research focused primarily on best practices, which are usually overlooked. Based on the schedules evaluated and sessions of structured interviews with experts, Moosavi and Moselhi, (2012) extracted criteria for a good quality schedule. They had an initial draft of more than sixty best practices which was refined to a final draft of forty seven criteria including conceptual provisions as well as quantitative criteria. The conceptual provisions focus mainly on the process of schedule development while quantitative criteria impose some thresholds on numeric schedule components such as durations, lags and total floats. The developed criteria were divided into three major categories concerning different aspects of construction schedules and schedule development process; contractual compliance, and schedule components. The criteria classification is illustrated in Figure 1.

Construction schedules are used by many stakeholders during all phases of the construction project, from inception to completion, (Mattila and Bowman, 2004). Construction schedule serves different purpose for each organization involved in the construction process. The building owner needs a schedule to advise when a project will be completed and also to identify different milestones in the project. If the schedule is properly followed, the project may have an increased chance of being completed on time and within budget. Contractors and subcontractors involved in the job need a schedule to determine resource requirements, when the resources will be needed, and when they must perform the work. Additionally, schedules can assist material vendors to know when and how much material to deliver to the Job-site. Much of the prior research done on schedule quality and schedule accuracy has been in the area of delay analysis (Kraiem and Diekmann 1987; Yates 1993; Knoke and Jentzen 1994; and Kallo 1996). The majority of these research works imply that the as-built schedule of a project may be different from its as-planned schedule (Kraiem and Diekmann 1987; Trauner 1990; Shi et al. 2001). The difference is often considered a delay (Trauner 1990; Arditi and Robinson 1995). Part of this inaccuracy might be attributed to inaccurate estimation of activity duration, usually an overestimation (Goldratt 1997).

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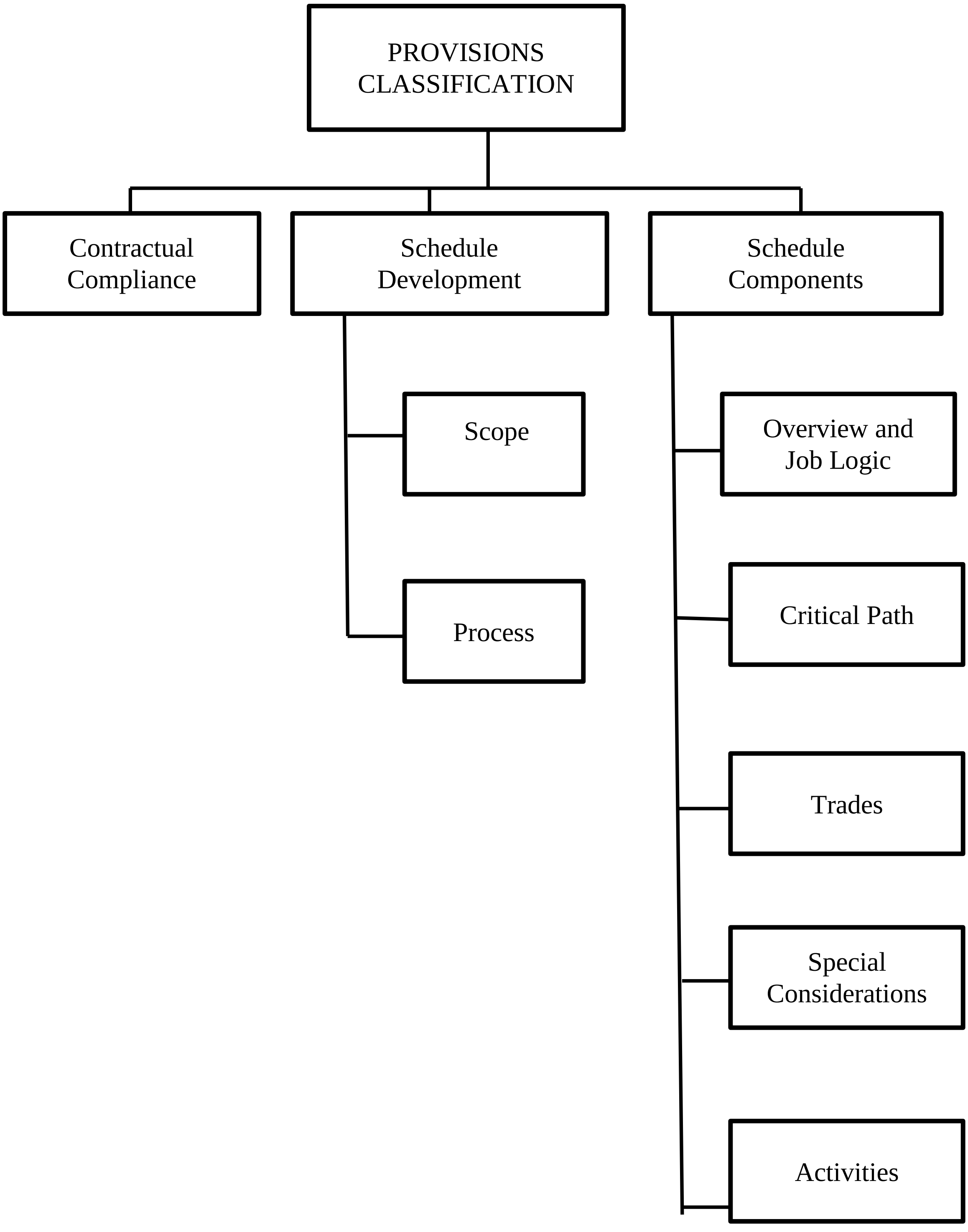

Figure 1. Construction Scheduling Criteria Classification.

Source: Adapted from Moosavi and Moselhi, (2012).

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However prior to this analysis of the difference between the as-built schedule of a project and its as-planned schedule, at the stage before contract award, the builder's schedule should be evaluated to assess if during implementation the difference between the as-built schedule and the as-planned schedule (which is an important schedule quality indicator) will likely be minimal. There are many pieces of scheduling software commercially available. Their role has focused mainly on developing usable plans before start of construction but do not evaluate developed plans to optimize them in response to actual progress challenges, (Hegazy and Petzold, 2003).

Due to the fact that construction schedules are affected by uncertainties in weather, production logistic, design scope changes, site conditions, soil properties, material delivery time, information request and information release problems, equipment efficiency, etc, (Edwards, 1995; Flanagan and Norman, 1993 in Ökmen and Öztaş, (2008), schedules need to be evaluated to ensure a reduced effect of these risks, uncertainties, unexpected situations, deviations, and surprises. All activities, even those that are not critical according to the deterministic CPM are potentially critical due to the occurrence of these uncertainties.

Al-tabtabai and Alex, (1999), opines that the purpose of evaluation is to find sub-optimum and optimum solution(s) to the problem domain. It should explore the solution space in an intelligent manner to evolve better solutions in the domain optimization process. Construction project managers often make optimization decisions (which should be evaluated) relating to different aspects of construction operations: (i) Optimization of resource utilisation to achieve project objective of cost reduction. (ii) Reduction of start date variability which could otherwise result in increased direct as well as indirect cost because of the off-on movement of crews and possible idle crew time and (iii) Reduction of start time variability in order to reduce the uncertainty in levels of material stockpiles, inventory, or material buffer. Decisions involving optimization in construction mainly involve a maximization or minimization problem subject to various influences and constraints that affect the decision, (Al-tabtabai and Alex, 1999). Defining and evaluating all feasible combinations of solutions based on the problem constraints and dependencies should be considered. The schedule should be evaluated for time, cost, and resource use effectiveness, (Hegazy and Ersahin, 2001). Time and cost are the evaluation factors to assess the effectiveness of a construction schedule. These factors indicate the effectiveness of the overall construction plan and should highlight particular areas of ineffectiveness where improvements could be made. Decision makers in the construction process should search for optimal or near optimal resource utilization schedules that minimize construction cost and time while maximizing its quality, (Cristóbal, 2009). Evaluation results may indicate that there is a difference between project performance of early start schedules than those of late start schedules in terms of activity start variability. It has been shown previously in that activity start date variability results in increased direct as well as indirect cost because of the off-on movement of crews and possibility of idle crew time.

The technical soundness of construction schedules should be assessed because there is a proven correlation between technically correct schedules and project outcomes, (Cristóbal, 2009). The tools to run schedule correctness checks are listed in Weaver, (2005) as: Acumen Fuse; Schedule Analyzer and Schedule Inspector. Weaver, (2005), further points out that useful information for assessing the technical correctness of construction schedules can be obtained from the DCMA 14-point schedule assessment guide and the GAO schedule assessment guide. The Defense Contract Management Agency (DCMA) is a division of the department of defense (DOD) that interacts directly with defense suppliers to ensure that DOD supplies and services

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are delivered on time and at the planned cost. DCMA has duties before and after contract award. After contract award, DCMA monitors contractors' deliverables to ensure that expenditure, project progress and schedules are in compliance with the contract.

Hegab, (2010a), posits that DCMA proposes a number of metrics that examines the health of the schedule and assesses its robustness. These standard metrics are called the DCMA 14-point schedule assessment metrics. These assessment metrics lists 14 individual checks to assess the quality and structural integrity of a project schedule. A number of base statistics need to be calculated before starting the check. These statistics are:

(i) Total Tasks - They are all the tasks except tasks that represent summary, subproject, zero duration, or milestones tasks.

(ii) Complete Tasks - They are the tasks among the "Total Tasks" that have 100% completion and with an actual finish date before the status date.

(iii) Incomplete Tasks - They are the tasks among the "Total Tasks" that do not have 100% completion and with an actual finish date before the status date.

(iv) Baseline tasks - They are the tasks among the "Total Tasks" that should have been completed before the status date in the original baseline schedule.

After identifying and calculating these base statistics as defined, the following checks are performed, (Hegab, 2010a):

1. Logic Check
2. Leads Check
3. Lags Check
4. Relationship Types Check
5. Hard Constraints Check
6. High Float Check
7. Negative Float Check
8. High Duration Check
9. Invalid Dates Check
10. Resources Check
11. Missed Tasks Check
12. Critical Path Test Check
13. Critical Path Length Index (CPLI)

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14. Baseline Execution Index (BEI)

It is important to perform these quality checks on the schedule, either by the scheduler or whoever is to accept the schedule before contract award. Evaluating the schedule using these quality check guidelines is important and knowing what to check in the evaluation process is even more critical. Below are four recommended schedule quality checks that are of direct relevance to this research based on the listed 14-points to ensure a sound and quality schedule, (Weaver, 2010).

1. Logic: This may sound almost silly, but it's one of the most common points of oversight.

Is the schedule logic sound? Are there tasks that have no predecessors or no successors? Are there redundant logic links or overly complex logic? It is important to run different types of diagnostics to ensure things flow smoothly and not caught up in too much detail. Figure 5 refers.

2. Float: It is nearly impossible to know precisely how long a project will take. This is because some of the floated activities have "float" time that may or may not be partially or fully built into the schedule. How much of float have been consumed? Is there enough float, or perhaps too much? Scheduling the floated activities to start as early as possible results in a schedule with zero float. On the other hand scheduling floated activities to start as late as possible results in a schedule with too much float in-built into it. This check is the main focus of this research. It is both an exploratory and a confirmatory study to identify the correct application of float consumption in different project scenarios.

3. Duration: Every task duration is unique. Some tasks will take a day, a week, a month, or a year. Activities with very long durations can be broken down into several shorter tasks.

4. Constraints: Defined as imposed dates of activity start and or activity finish. It is important to remember always that constraints really go against the premise of a naturally flowing CPM network. The key here is to realistically plan the schedule with logic dictating the start and finish dates of activities. While there are some cases where using a constraint is appropriate, they should be avoided as much as possible and the project should be scheduled using the calculated default options if practicable.

Some of the evaluation check list proposed in the DCMA 14-points assessment check are now briefly discussed, (Hegab, 2010a):

(1) Logic Checks

This is used to identify any activity that is missing a successor or predecessor or both. As a rule of thumb in scheduling, all activities have to be tied to at least one predecessor and one successor. This check does not confirm the correctness of the tie which has to be verified manually. The value is calculated as the number of activities that are missing a logic divided by the number of incomplete tasks. For the schedule to be acceptable its value should not exceed 5%.

(2) Leads Checks

This is used to check the existence of any leads in the schedule because using leads in the schedule may create disturbance to the critical path and resources. The check is performed by

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identifying any activity that its predecessor has a lead. The value is calculated as the number of tasks that have a lead. For the schedule to be acceptable its value should not exceed 5%.

(3) Lags Checks

This is used to check the existence of any lags in the schedule because using lags in the schedule may create disturbance to the critical path. The check is performed by identifying any task with a predecessor that has a lag. The value is calculated as the number of tasks that have a lag divided by the number of incomplete tasks. For the schedule to be acceptable its value should not exceed 5%.

(4) Relationship Type Checks

This check validates the type of relationship between the task and its predecessor assuming that most activities are tied by Finish to Start (FS) relationship and a much lower percentage is linked by Finish to Finish (FF), Start to Start (SS), Start to Finish (SF) relationship. This check is performed by identifying the relationship type of any task that has a predecessor. It is calculated as the number of tasks that have FS, FF or SS relationships divided by the number of incomplete tasks. For the schedule to be acceptable the percentage of tasks with FS relationships should not be less than 90% and tasks with SF relationships its value should not exceed 0%.

(5) Hard Constraints Checks

This is used to identify any activity that has a hard constraint (such as Must-Finish-On, Must-Start-On, Start-No-Later-Than, and Finish-No-Later-Than). Hard constraints do not allow logic to drive the schedule. The check is performed by identifying any task that has a hard constraint. The value is calculated as the number of activities that has hard constraint divided by the number of incomplete tasks. For the schedule to be acceptable its value should not exceed 5%.

(6) High Float Checks

This is used to identify any activity that has a total float of more than 44 working days (2 month). High float may result from logic inaccuracy or missing relationships. The check is performed by identifying any task that has a total float exceeding 44 working days. The value is calculated as the number of activities that have high float (more than 44 working days) divided by the number of incomplete tasks. For the schedule to be acceptable its value should not exceed 5%.

(8) High Duration Checks

This is used to identify any activity that has an original duration of more than 44 working days (2 month). Such a high duration may indicate the need for further breakdown to enhance the cost and time control. The check is performed by identifying any task that has an original duration exceeding 44 working days. The value is calculated as the number of activities that has high duration (more than 44 working days) divided by the number of incomplete tasks. For the schedule to be acceptable its value should not exceed 5%.

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(10) Resources Checks

This is used to identify any activity that does not have resources or cost applied on it. The check is performed by identifying any task that is “Incomplete Task”, “Total Task”, and does not have resources or cost applied on it. The value is calculated as the number of activities that do not have resources or cost divided by the number of incomplete tasks. For the schedule to be acceptable, its value should not exceed 0%.

(12) Critical Path Test

This is used to assess the integrity of the schedule specially the critical path. It is one of the two Trip Wires that are required by the office of Secretary of defense. The check is performed by adding an intentional delay (600 working days) to the remaining duration of a critical task and then verify if the project completion date is delayed by a proportional duration (600 working days). By adding such a delay, any missing predecessors or successors will lead to a mismatch between the project overall delay and the intentional one. The check is passed if there is a matching between the project completion delay and the intentional added duration.

(13) Critical Path Length Index (CPLI)

This is used to assess if the project finish date will be real or not. It is one of the two Trip Wires that are required by the office of Secretary of defense. It is calculated by adding the length of the critical path to the total float of the latest activity and divide the summation by the length of the critical path. For the schedule to be acceptable, its value should not exceed 5%.

(14) Baseline Execution Index (BEI)

This is used to assess the number of completed activities to date with respect to those planned to be completed in the baseline. It is one of the two Trip Wires that are required by the office of Secretary of defense. It is calculated by summation of completed tasks and dividing it by the baseline count. For the schedule to be acceptable, its value should not be below 95%.

The U.S. Government Accountability Office (GAO) is an independent agency that supports the congress by watching and investigating the expenditure of the federal government (Hegab, 2010). The GAO helps the congress by auditing operations to ensure that Federal money are spent expeditiously and effectively; investigating allegations of extrajudicial and improper activities; validating the compliance of government programs and policies to their objectives; analyzing policies and suggest options for the congress; and issuance of judicial decisions and opinions, such as bid protest rules and reporting. It is known as the “congressional watchdog”. As part of GAO’s auditing process, program’s cost and schedule are checked in relation to the 9 scheduling best practice discussed below, (Hegab, 2010). Every project that is federally funded is subjected to GAO’s auditing either by the agency representative or by contractor tendering for the works. The schedule should meet GAO’s best practice guidelines metrics. The GAO Scheduling Best Practice 9 criteria to achieve a reliable and cost effective schedule are, (Hegab, 2010):

1. Capturing all activities: As a basic requirement, a program’s schedule should include all activities under the work breakdown structure (WBS).
2. Sequencing all activities: Activities should be linked with relationships similar to the order

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it is intended to follow in execution of their successors and predecessors. Constraints, lags, and lead time should be logical and shown to be needed, not redundant.

3. Assigning resources to all activities: Schedules should be resource loaded (with labor, materials, equipment) to make sure of their availability during execution and identify any time or funding constraints.
4. Establishing the duration of all activities: Schedules should maintain duration that realistically match the cost plan.
5. Integrating schedule activities horizontally and vertically: Schedules should use realistic predecessors and successors and should allow concurrency of unrelated activities.
6. Establishing the critical path for all activities: With the help of scheduling software, the critical path (longest path) should be identified to check its accuracy and the effect of slippage of program activities on its finish date.
7. Identifying float between activities: The free float and total float between related activities should be determined to figure the effect of slippage of activities on its successors and the project completion due date. The float consumed or built into the schedule should be reasonable. And investigating the correct amount for different tasks is the main subject of this research.
8. Conducting a schedule risk analysis: A schedule risk analysis should be performed to identify the risk of potential delays, the probability of meeting the planned completion date, and the needed schedule contingency to complete the program with a certain confidence level.
9. Updating the schedule using logic and duration to determine the date: The logic and actual start and finish dates of activities should be monitored to identify the actual completion date and confirm its compliance with the planned completion date. Logic override and unnecessary constraints application should be avoided.

A comparison of the GAO's schedule quality criteria and the DCMA 14-point check suggests that there is some similarity between these two schedule quality assessments. It should be noted that aside from DCMA and GAO, there are other sources that provide project schedule guidance - how to build a sound quality schedule, what to include in it and what to check to optimize it. These resources are abundantly available in the literature and it is imperative for

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project managers to become familiar with these resources and follow the guidelines provided. Below are some examples of available resources:

- DCMA 14 Point Schedule Metrics for IMS (Project/Open Plan, Etc.) Analysis
- U.S. Government Accountability Office (GAO) Best Practices
- Independent Project Analysis (IPA) Guidelines
- Project Management Body of Knowledge (PMBOK) Guidelines
- AACE International (Authority for Total Cost Management) recommendations
- National Defense Industrial Association (NDIA) Generally Accepted Scheduling Principles (GASP)

Core traits of a reliable schedule presented in Weaver, (2010) is less prescriptive than the DCMA 14 Point Schedule Metrics. These core traits of a reliable schedule are aimed at codifying schedule best practices. It gives the essentials of a reliable schedule. It organises established and emerging best practices for CPM schedules into 20 core traits which could be grouped broadly into four main categories as:

(A) Traits that correspond to comprehensive schedules,

(B) Traits that correspond to credible schedules,

(C) Traits that correspond to well-constructed schedules, and

(D) Traits that correspond to controlled schedules.

The 20 best practices developed from these four traits are, Weaver, (2010):

(A1) Aligned - The schedule portrays a viable plan that aligns with the planning basis, subcontractors' schedules, and materials/components procurement system.

(A2) Complete - The entire work, including specified responsibilities of the owner and third parties, is fully captured in the activities, logic relationships, and events.

(A3) Conforming - The schedule complies with contract dates, sequences and other imposed contract conditions

(A4) Formulaic - Physical work activity durations are largely formulaic, or are endorsed by those who will perform the activities, and align with the schedule level.

(A5) Resourced - The schedule reflects the resources needed, their availability to support the rate of progress, and known availability limits.

(B1) Predictive - The schedule establishes valid critical and near-critical paths; in the initial

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schedule, the critical path has total float ≤ 0.

(B2) Risked adjusted - Using risk assessment, the schedule is established with schedule margin sufficient to support the targeted probability threshold.

(B3) Weather-Fitted - The schedule correctly integrates normal adverse weather according to the controlling specifications and best practices.

(B4) Resource Flow - This should portray crew movements, equipment logistics and work-flow.

(B5) Flexible - The schedule has enough flexibility adequate for mitigating delay and floating for resource leveling.

(C1) Hierarchical - The baseline is fully developed as a level 2 schedule that serves as the basis for, and remains traceable to subsequent revisions or level 3 schedules.

(C2) Phased - Construction phases from site work to closeout are aligned with the planning basis

(C3) Logical - Finish to Start logic is favoured; constraints, lags, leads, and Finish to Finish logic are used judiciously and, when used, should be justified.

(C4) Connected - Every activity has at least one Finish to Start or Start to Start predecessor and one Finish to Start or Finish to Finish successor; paired Start to Start/ Finish to Finish logic is used judiciously.

(C5) Calendar Fitted - Calendars used to calculate the schedule should reflect the planning basis, the working schedule, and other limiting factors.

(D1) Statused - The schedule is accurately statused using reliable, documented protocols; subsequent or imminent level 3 schedule activities are resource levelled.

(D2) Weathered - The schedule is used to evaluate weather delays and/or gains originating from actual weather conditions in the prior months.

(D4) Forensic- In a statused or revised GPM schedule, the critical path is identified left of the data date (from the project start event to the data date).

(D5) Trended - Activity rate of completion is sufficient so that the scope of remaining activities is congruent with an achievable rate of progress

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OTHER SCHEDULE EVALUATION AND SCHEDULE VALIDATION TOOLS

Inaccurate schedules do not help to achieve project success. Schedule analysis helps the project team to: Build a better schedule; Improve project confidence; and Achieve successful-on-time and on-budget completion. Acumen Fuse enables project teams not only to calculate schedule conformance score, but to pinpoint the weaknesses driving that score and immediately correct them. It is a comprehensive project analysis, visualization and problem resolution platform that complements existing scheduling tools to:

- build sound, realistically achievable schedules without manual critique;
- provide the process with checks and tracking necessary for understanding schedule quality, cost forecast accuracy, risk model realism, earned value and performance
- give a repeatable way to pinpoint weaknesses and gauge the impact of schedule changes.

THE SCHEDULE QUALITY

Until recently scheduling was regarded as an art with only subjective opinions as to what constituted a good quality schedule, (Weaver, 2010). Any debate over schedule quality tended to be confused with arguments over personal preferences in tools and/or networking techniques. The publication by PMI of its Practice Standard for Scheduling in May 2007 went a long way towards resolving many of the issues of what constitute a quality schedule, a schedule that does not promise the impossible, (PMI, 2009). The PMI Practice Standard for Scheduling standard development team drew on expertise from around the world to deliver an authoritative document that defines a good scheduling practice. The definition of 'good practise' as set out in the Standard is based on the 'Time Management' processes from the PMBOK Guide 3rd Edition. This provides guidance on generally accepted good practice for the development of an effective schedule for a project, (Weaver, 2010).

The Standard is not a text book on scheduling but does lay out the principles that underpin the development and use of an effective project schedule. From a quality perspective, the list of 'Scheduling Components' and the associated 'Conformance Index' provide a tool that allows the unambiguous assessment of the technical competence of a schedule. A 'schedule component' is a data element that should exist in a schedule model (eg Activity Duration). Each component is defined in terms of:

- Its name
- If it is required for a minimally conforming schedule or optional
- If the data is manually entered or calculated, automated
- The format of the data (text, numeric, date, etc)
- The behaviour of the component (how it reacts or enables a reaction within the tool)
- Good practice in the use of the component
- Additional notes and associated components, considered in this thesis
- A definition of the component

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The conformance scoring system first checks to ensure all required components are present, then calculates a score based on the use of all components. Whilst this tool provides a very useful mechanism for measuring the technical competence of a schedule, it does not address the best practice guidelines outlined in measuring the 'effectiveness' or 'usefulness' of the schedule. The Practice Standard for Scheduling is a major improvement but it explicitly acknowledges that it focuses on technical conformance rather than the usefulness of the schedule. (Though it is inferred that if the schedule truly technically conform, then it should be effective and useful). This introduced the important point that there is a difference between technical conformance of a construction schedule and its effectiveness or usefulness. The challenge for future edition will be to focus more on the subjective areas of relevance and usefulness, (Weaver, 2010). In the meantime, PMI's College of Scheduling is working on the Scheduling Excellence Initiative which is currently focused on developing and publishing the Scheduling Enhancement Series-a multi-volume reference centre for scheduling concepts, methodologies and best practice.

Why do building owners or their representatives accept poor quality schedules? The need for effective planning and scheduling has been recognised for well over a 200 years. Projects fail when they overrun the allotted time and budget. Overrunning on schedule almost invariably lead to overrun on cost, (MOSAIC, 2010). The elements needed to improve the probability of project success are also well known, starting with a skilled project manager and team, with the necessary knowledge, skills and experience. The next layer of support to build success is making sure the 'right' PM tools, processes and methodologies are used; again these are hardly new, they are well known and would include:

- Ensuring project stakeholders are managed; their expectations and/or perceptions are identified and managed, and their involvement sought as necessary;
- The timely management of risk, threats and opportunities;
- Ensuring alignment of outcomes to organisation strategy;
- Scope and costs are identified and managed, and
- Ensuring appropriate and effective, planning & scheduling

Schedules are useful in two key areas; the schedule's primary purpose is communication not control; after all documents cannot 'control' anything! A useful schedule can influence decisions and actions by highlighting key decision points and the opportune time to make the decision. The second key area is coordination. Projects involve a range of different resources that need to work on the activities in the 'right sequence' to support the work of other resources and optimise the overall delivery of the project. Good schedules are capable of providing and assisting in coordination, control and stakeholder communication. But to be useful, schedules have to be technically correct and usable by the project team. This requires good planning, good scheduling culture within the organisation and building a project team that values effective time management. This strong correlation between technically correct schedules and project outcomes is illustrated in Figure 2. For a building client, a project sponsor, a project review team member or portfolio manager, there is need to test the quality of a project schedule before recommending contract award. The key questions to ask includes: Is the scheduler qualified? Was the management team involved in its preparation? Is the schedule technically correct? Evaluation and regular checking of the schedule seems to drive improved technical

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performance. Available tools used to run schedule checks or do schedule evaluation are: Acumen Fuse, Schedule Analyzer, Schedule Inspector, SCRAM, the application of DCMA 14-Point schedule assessment and GAO Schedule Assessment Guide. These tools may assist to ascertain if the schedule is sensible reliable and argued earlier, it is not promising the impossible. This is though difficult to assess because to a degree it is subjective. Elements to consider include: Is risk and uncertainty proactively considered? If there is no consideration of risk the schedule will likely fail.

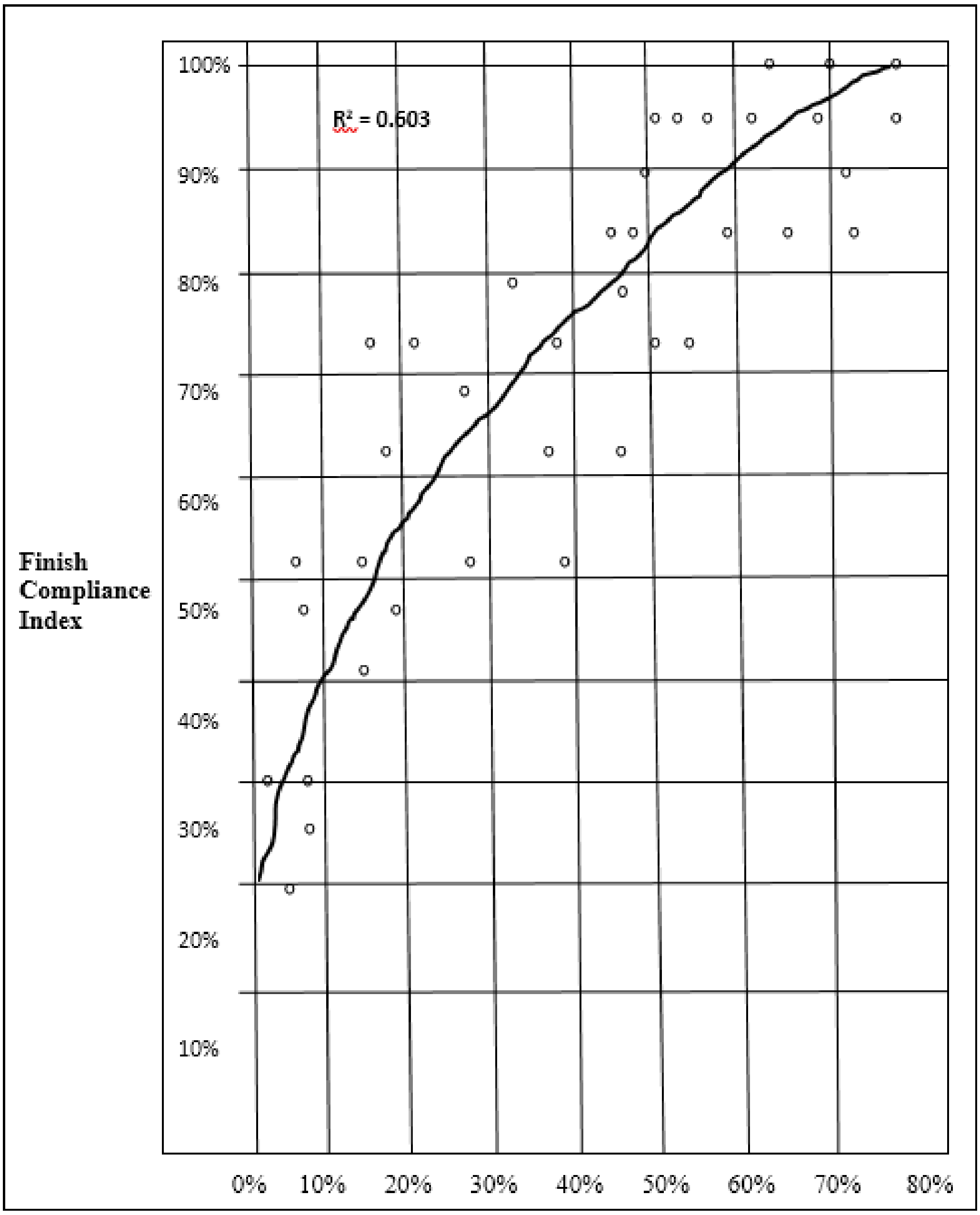

Figure 2 The Correlation between Schedule Quality Index and Finish Compliance Index

Source: MOSAIC, (2010)

Though it is acknowledged that no one can accurately predict the future because there is always a plus or minus degree of certainty. How was the risk modelling done? Is the level of detail appropriate for the current level of available knowledge? What planning was done prior to starting schedule development? MOSAIC (2010) concludes that asking these questions is one thing, providing adequate funding and support to allow the project team to create positive answers is another! When considering these options, it should be remembered that a good schedule will not guarantee project success; but surely a poor schedule will guarantee project failure, particularly on complex projects! There's no excuse for accepting bad schedules! Evaluating and validating the project schedule is a sure way to ensure effective project delivery. Kaelble, (2014) and Weber, (2015), listed five similar key steps in construction schedule development which could produce a good quality, well optimized schedule. Figures 3 and 4 show these key steps each of which produces a type of schedule of different quality. The first step produces S1 schedule, the second, S2 schedule and so on. Kaelble, (2014), called them the five-stage schedule maturity framework, illustrated in Figure 3. And Weber, (2015) called these steps the Five-Stage Framework for Project Success. These steps necessary to produce good quality, well optimized schedules are listed and discussed below:

- The schedule basis, S1
- Critiquing the schedule, S2
- Analyzing schedule risk, S3
- Optimization, S4 and
- Gaining team buy-in, S5

The schedule basis, S1: Is the starting point and it represents the schedule that is not-critiqued, non-evaluated, and non-risk-adjusted. This schedule is used as a baseline for the journey toward schedule improvement.

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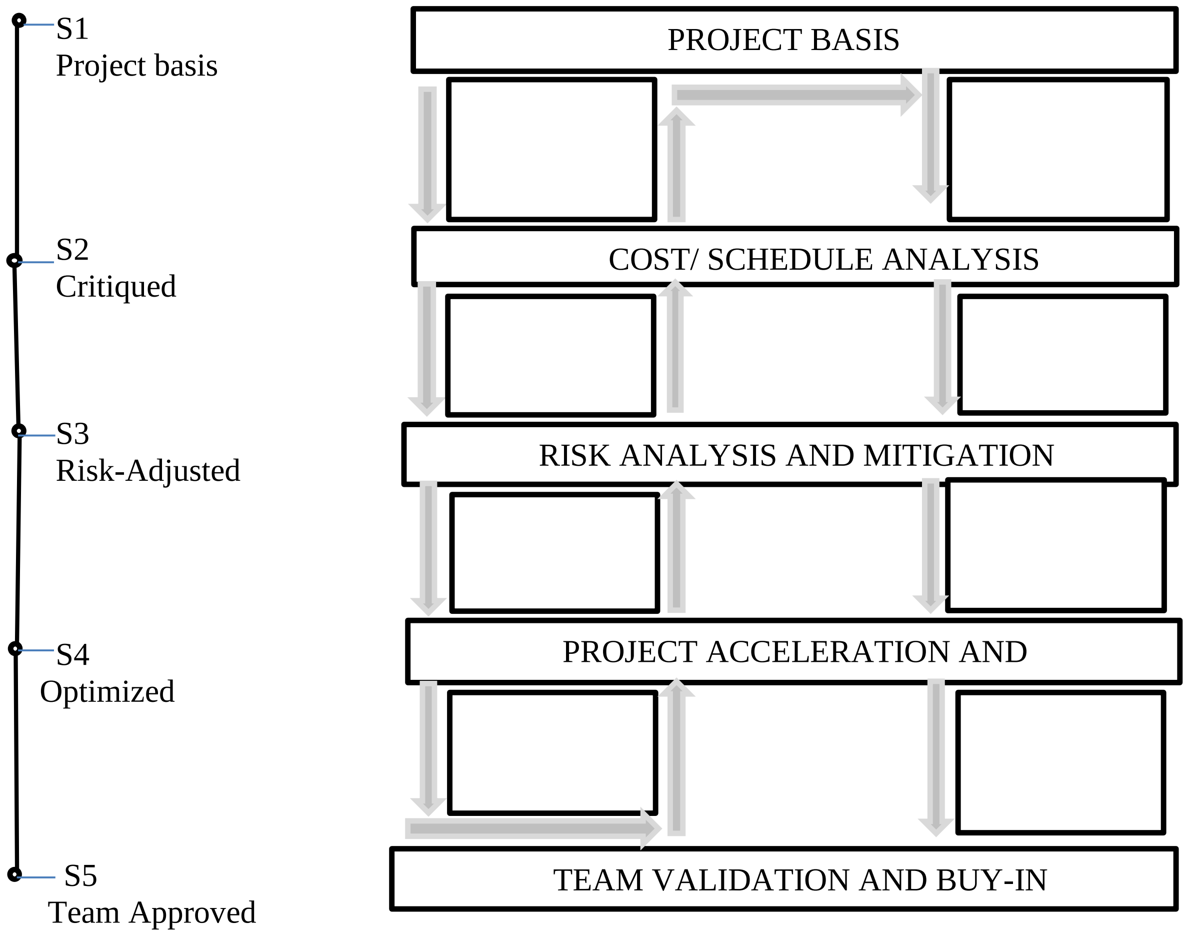

Figure 3. The Five-Stage Schedule Maturity Framework

Source: Kaelble, (2014)

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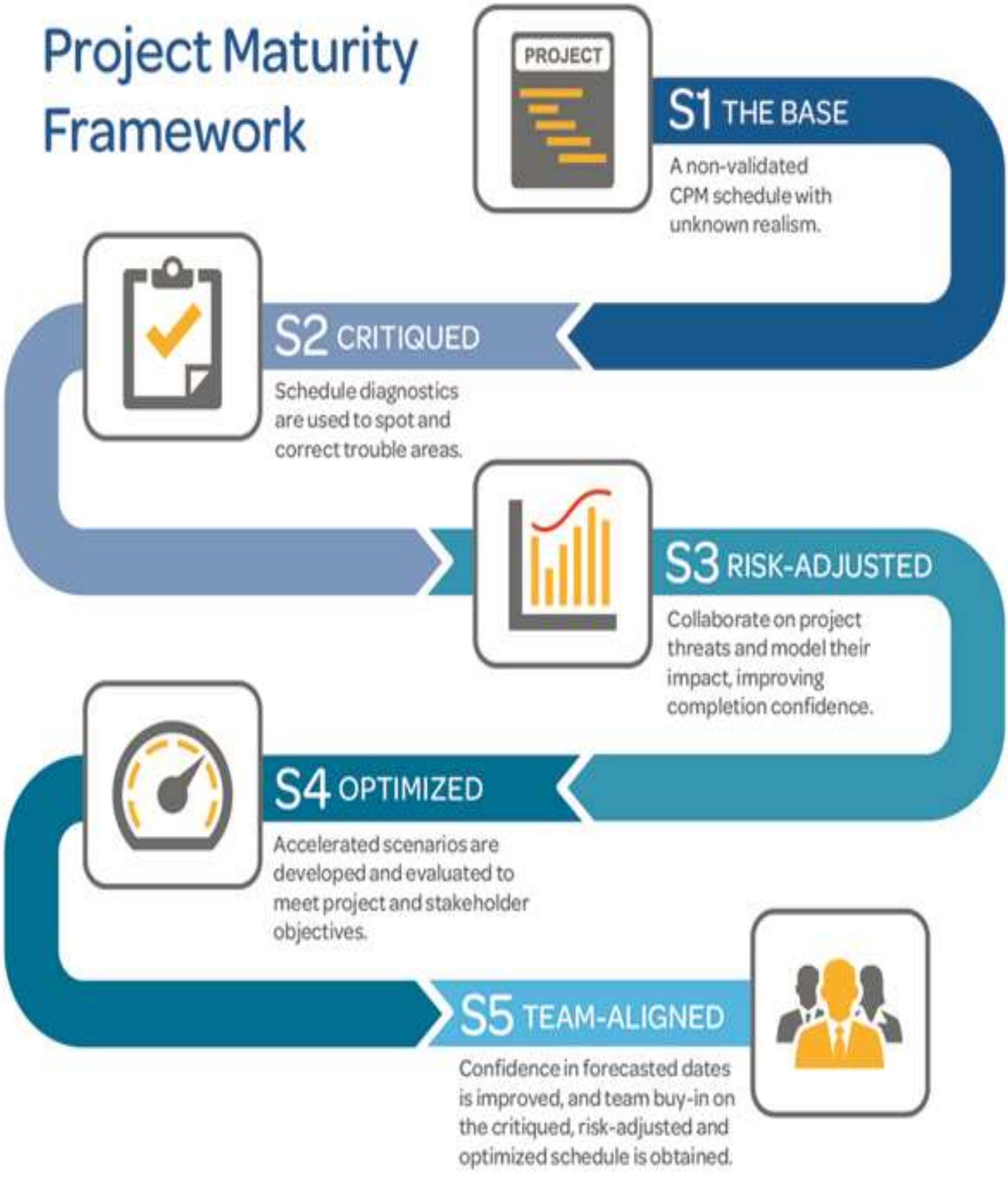

Figure 4. A Five-Stage Framework for Project Success.

Source: Weber, (2015).

Diagnostics or critiquing the schedule, S2: The task in step 2 is to figure out how the S1 schedule can be improved by evaluating it. Examples of metrics available for critiquing the schedule as discussed earlier include logic, free-flowing logic, missing logic, redundant logic, logic density and amount of float consumption. CPM scheduling has been advanced to the next level by such developments as:

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- DCMA's 14 Point Schedule Assessment criteria,
- GAO Schedule Assessment Guide and
- Deltek's metric-based philosophy on planning.

Different organizations use different criteria as assessment metrics to assess schedule quality. The widespread adoption of metrics as a way to critique project schedules has without doubt been one of the biggest advances in CPM scheduling in recent years. The value of metric analysis goes beyond promoting better quality schedules. The newer, younger generation of CPM planners can now apply these schedule check metrics to learn and self-assess when building CPM schedules, ensuring that the process models they build are as feasible as possible. This is a huge step in the right direction with regard to more realistic scheduling. The question of what metrics to use to assess schedule quality is important. Here are some core metrics that are invaluable when establishing a sound quality schedule. There are plenty of other metrics, of course. As an example, Deltek Acumen Fuse has hundreds of metrics available for critiquing project schedules.

(i) Missing Logic: In theory, all activities should be associated with at least one predecessor and one successor (except, of course, the project's start and finish activities). Making certain there is no missing logic ensures an accurate set of logic paths through the schedule.

(ii) Logic Density: This metric calculates the average number of logic links per activity. If average is less than two, it's likely that there are some missing logic. On the other hand, an average greater than four suggests a complex logic, with a high likelihood of redundant links.

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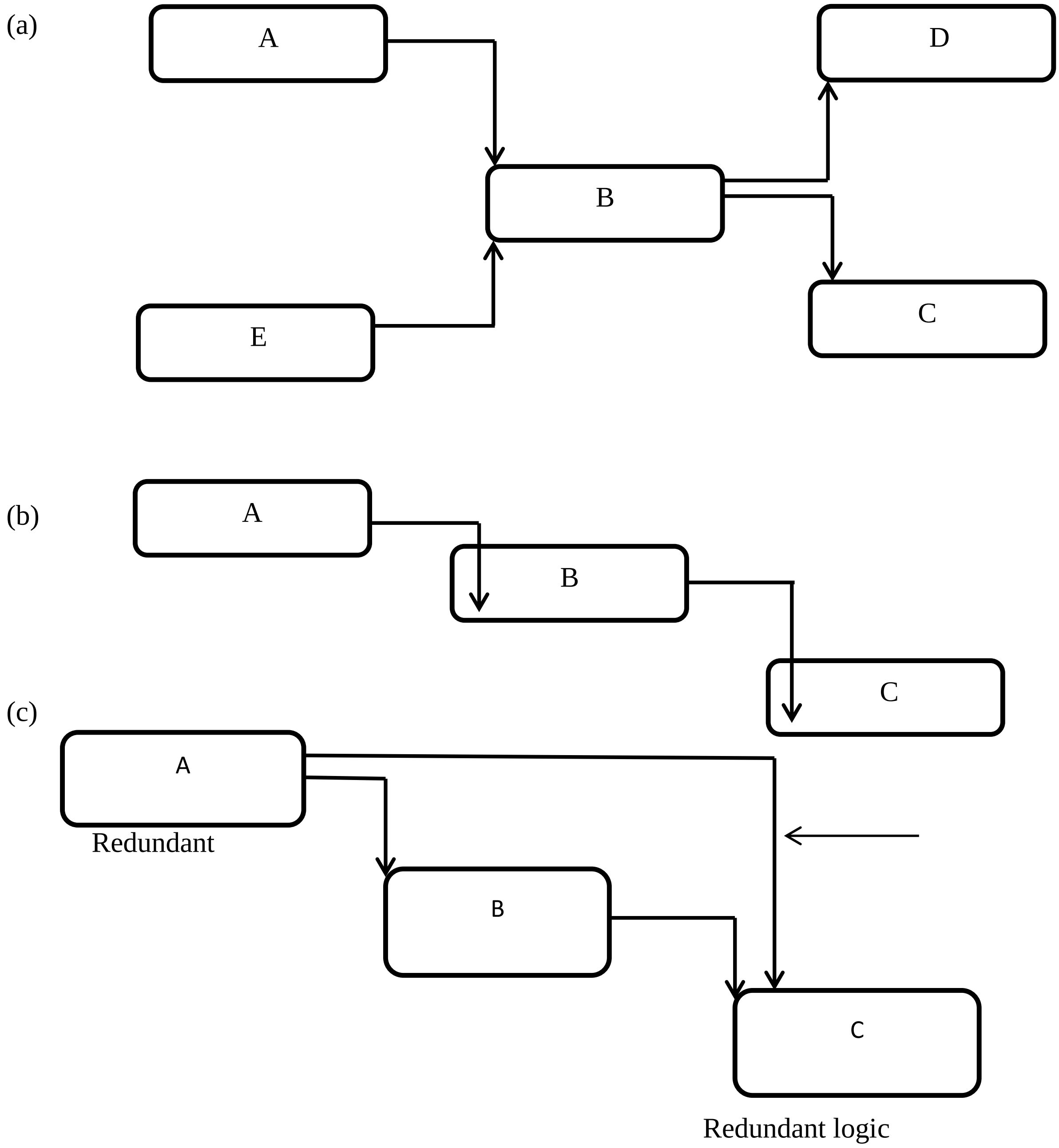

Figure 5. Activity B has a Logic Density of 4 and 2.

Source: Kaelble, (2014)

Therefore, logic density should fall between two and four. This is an incredibly useful metric in assessing and evaluating the schedule. It's a great indicator of where and when in the schedule there is insufficient logic, or where the logic is overly complex. Figure 5 shows activity B with a logic density of 4 in Figure 5a, a logic density of 2 in Figure 5b and a redundant logic in Figure 5c. Removing redundant logic helps make the project schedule clearer and also lessens the overhead of maintaining risk models.

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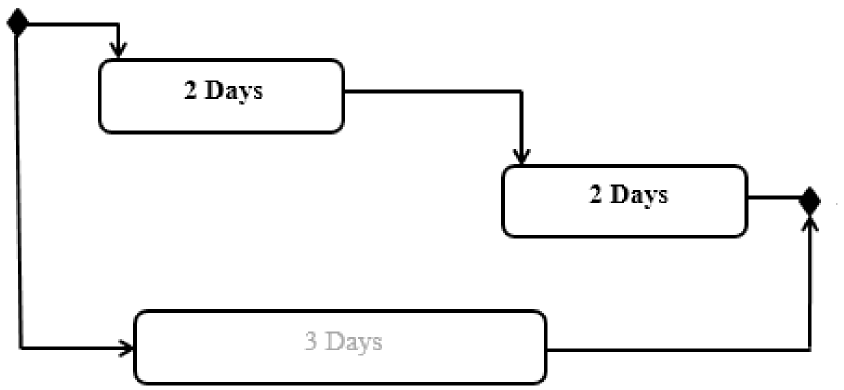
(iii) Number of concurrent critical paths: There's nothing inherently good or bad about critical activities in a schedule. It is, however, useful to analyze the number of parallel critical (or near-critical) paths. If the schedule has more than one critical (or near-critical) paths, there is likely more risky work fronts than would if the project had just a single critical path. What this indicates is that a schedule with a single big problem to solve is preferable over multiple medium-sized problems all occurring simultaneously. Figure 6 illustrates the difference between a dominant and Non-dominant path.

(iv) Hard constraints: Scheduling theory recommends avoiding hard or two-way constraints such as "Must Start On" or "Must Finish On." They're poor schedule-building blocks as they override the natural precedence making it not to occur naturally. However one-way constraints such as 'As soon as possible' and 'As late possible' could be used with caution. It is important to remember that constraints really go against the premise of a naturally flowing CPM network.

A SINGLE DOMINANT PATH



TWO DOMINANT PATHS

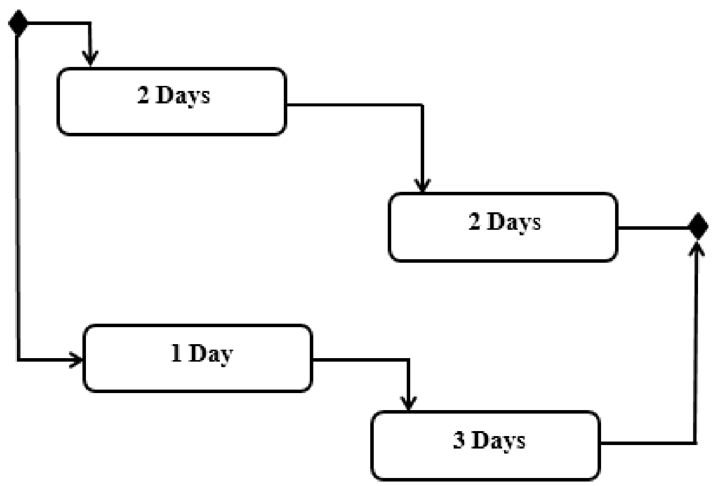


Figure 6. Comparing Scenarios of a Single Dominant Path with two Dominant Paths.

Source: Kaelble, (2014)

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SCHEDULE CONFORMANCE SCORING

The PMI's (Project management institute) 'practice standard for scheduling' and the 'scheduling excellence initiative' have defined practice standard for scheduling which places scheduling in the context of the project management body of knowledge guide and describes good scheduling practice, Weaver, (2009). Weaver describes the components needed for a good schedule and offers a 'conformance scoring' system for evaluating its effectiveness.

Schedule conformance evaluation should validate that all required components are present and that best practice is followed. The schedule conformance evaluation will show minimally conformance requirement indicating that it is possible to rate the technical competence of the schedule. Thus avoiding accepting "every schedule model'' as correct, because schedules that fail the schedule conformance evaluation will likely not communicate and effectively coordinate ideas about what might happen in the future, Weaver, (2009).

The most important criteria each schedule should satisfy are contractual provisions and schedule development best practice. These provisions could be considered as obligatory criteria because if submitted schedules are not in conformity with the contract, whether or not other criteria are satisfied, the schedule should not be accepted. Although such criteria seems obvious, it is the basic reason for rejection of many schedules (Li and Carter, 2005; Zartab and Rasmussen, 2001). This category encompasses the criteria that are directly related to the process of schedule development. Five provisions have been divided into two different sub categories; scope and process. Applying these provisions help users to assess the process of schedule development. These provisions are frequently overlooked although they were highlighted and stressed in several publications. For instance, a criterion which is called "Subcontractors Participation" was indicated in various references (De La Garza, 1988; Zack Jr., 1991). Even some references suggested a provision in some contracts requiring subcontractors to sign off on the schedule as verification of their commitment to the scheduled dates (Li and Carter, 2005). The same provision was suggested in another reference intended to prevent contractors from eliminating certain activities and from using unrealistic durations for submittals review (Zack Jr., 1991). This kind of repetition for a single provision in different references has been noticed for numerous criteria.

In conducting schedule review process, owners or their representatives should verify if the schedule is technically correct. They should ensure that job logic and activity durations are reasonable, (Booth, 1993., Booth, et al. 1989., Avalon and Foster, 2010 and O'Brien and Plotnick, 2010). Taking into account size and complexity of today's projects it is not uncommon to have schedules that consist of hundreds if not thousands of activities. It is obvious that manual evaluation of these schedules is burdensome if not impractical. Moreover, inherent in manual evaluation of schedules is ignorance of errors by schedule reviewer with increased number of activities, (Dzeng et al, 2005). Therefore, nowadays schedule evaluators have a complicated task in performing needed evaluation and assessments of schedules that encompass a multitude of activities. Computer implementation is applied to address this issue by automating the assessment, (Moosavi, 2012). The first level of assessment using a computer software is described in Moosavi, (2012).

The developed software application called "SAE" was coded using Visual Basic and implemented in Microsoft environment, (Moosavi, 2012). It consists of three main modules; GUI, Assessment Engine and the database. The GUI was coded using Visual studio 2008 based on application of Visual Basic. The interface is designed to interact with the Assessment

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Engine; providing the user with the flexibility to revise threshold values. The Assessment Engine module was developed as a macro in Microsoft Project 2007 by implementation of Visual Basic for Applications (VBA 6.5.1053) for MSP. Moosavi, (2012), further stated that the coded macro automates calculations needed to assess twelve quantitative provisions, job logic of selected construction trades and assessment of productivity and crew size considered for a number of commonly used trades in building construction. Third module of the developed software is a database. In order to store and retrieve required data pertinent to productivity and crew size associated with typical construction activities, a database was developed in Microsoft Office Access 2007 environment. The coded software is capable of producing reports after performing each tier of schedule assessment and evaluation. The flow of data through the SAE is shown in Figure 7. After applying automatic assessment and evaluation, the result is shown in excel file. The report includes calculated schedule components such as criticality rate, near criticality rate and project cost.

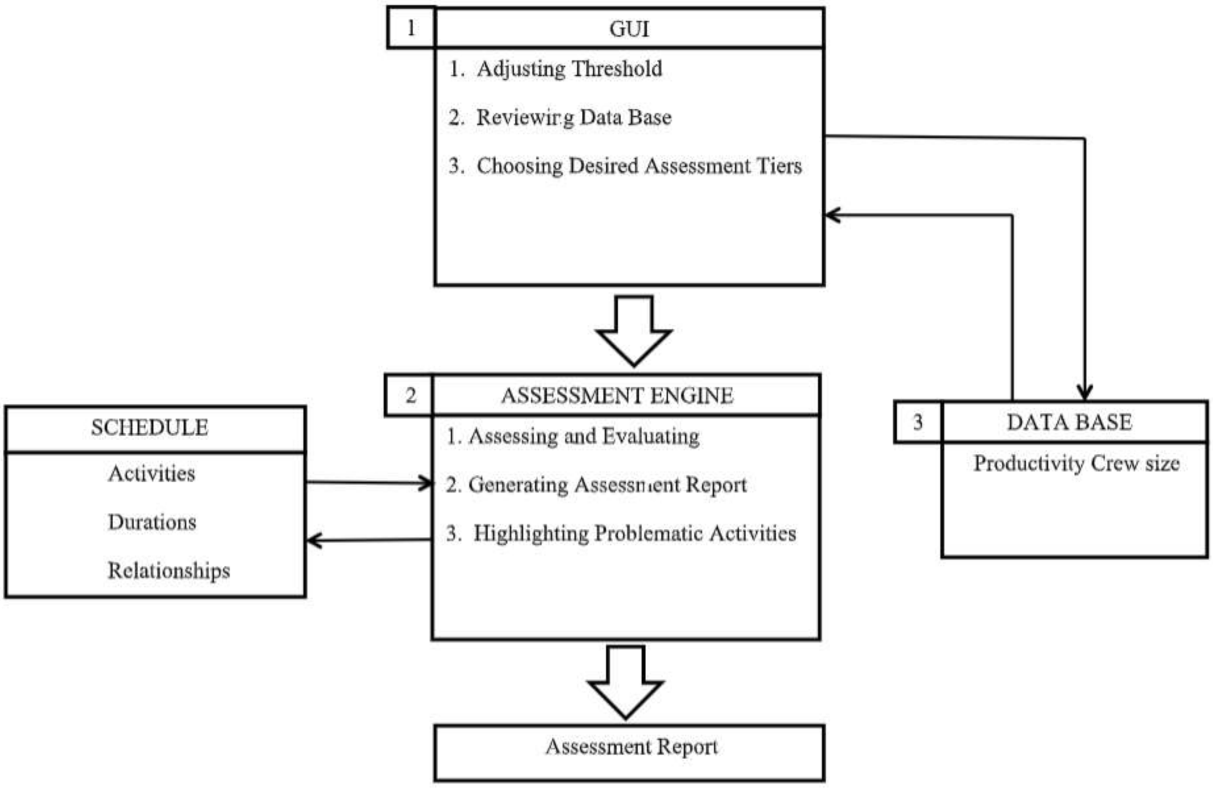

Figure 7. Flow of Data through the Schedule Assessment and Evaluation Process

Source: Moosavi and Moselhi, (2012)

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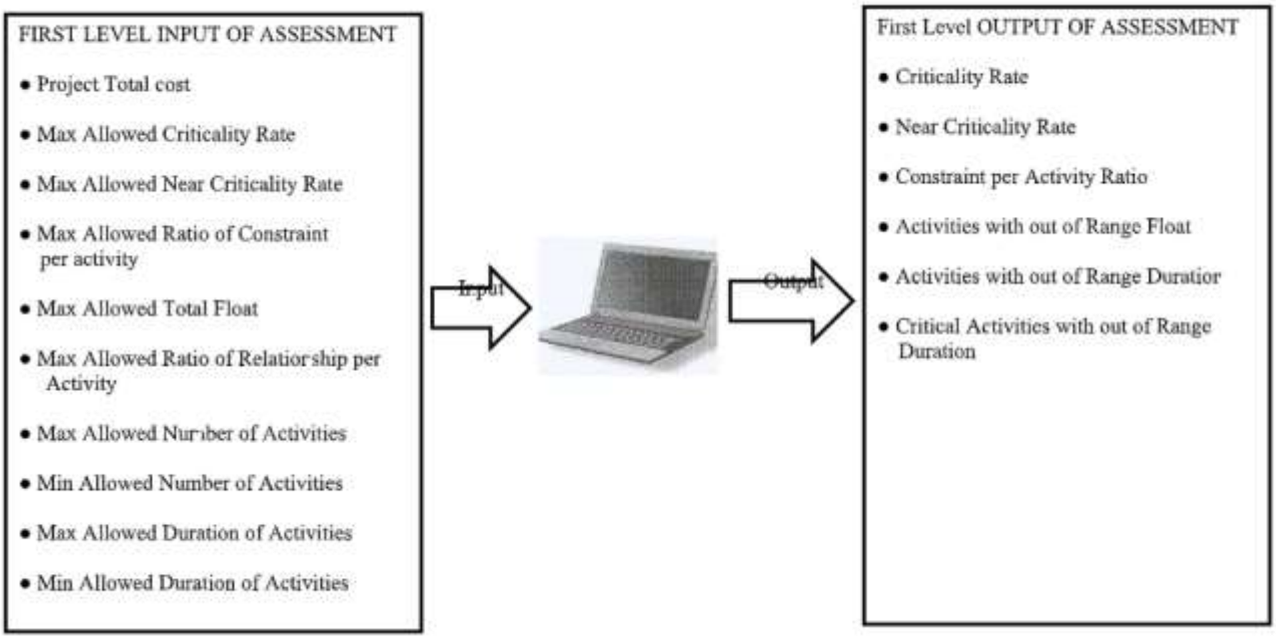

Figure 8. Input-Output Model of Schedule Assessment and Evaluation

Source: Adapted from Moosavi and Moselhi, (2012)

Table 1. Suggested List of Schedule Assessment and Evaluation Criteria

Schedule Assessment And Evaluation Criteria Evaluating how good a schedule is			
S/N	Element	Explanation	Source reference
1. Obligatory criteria			
1.1 Contractual Compliance			
1	Milestones & Project Duration	Milestones & project duration must be in line with related contractual provisions.	Spencer and Lewis 2006, De La Garza 1988
2	Phasing and Sequencing	Phasing and sequencing must be in line with related contractual provisions (if applicable).	Li and Carter, 2005
3	Number and Duration of Activities	Number and duration of activities must be in line with related contractual provisions (if applicable).	Li and Carter, 2005
4	Activity Code	Activity code must be in line with related contractual provision (if applicable).	Li and Carter, 2005
5	Schedule Submission Date	Schedule submission date should be in compliance with related contractual provision.	Zack 1991
6	Scope Coverage	Scope of the project should be covered by Schedule	Douglas 2009b, GAO 2009, PMI 2007, Li 2005

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1.2 Job Logic			
7	Job Logic	Job logic must be rational.	O'Brien and Plotnick 2010, Douglas 2009b , GAO 2009, De La Garza 1988
1.3 Duration			
8	Activity Duration (reasonability)	Activity duration must be reasonable.	O'Brien and Plotnick 2010, Douglas 2009b, GAO 2009
2. Complementary Criteria			
2. 1 Schedule Development			
2.1.1 Scope			
9	Project Scope Definition	All aspects of project scope should be adequately defined before scheduling	PMI 2007
10	WBS Verification	Scheduling should be based on an approved WBS	PMI 2007

Table 1. contd.

Schedule Assessment And Evaluation Criteria Evaluating how good a schedule is			
NO	Element	Explanation	Source reference
2.1.2 Process			
11	Scheduling Process	Schedule should be developed by participation of parties associated with the project	Li and Carter, 2005
12	Subcontractors Participation	Subcontractors responsible for considerable parts of project should become involved in schedule development having their work integrated and coordinated.	Li and Carter, 2005, Zack 1991, De La Garza 1988
13	Verification of Subcontractors' Scope of Work	The schedule should reflect the start and completion dates for prime contractors involved	Douglas 2009b, De La Garza 1988
2.2 Schedule Components			
2.2.1 Overview			
14	Verification of Project Duration	Project duration should conform with parametric scheduling results	Moselhi 2010
15	Minimum Milestones	At least two milestones, start & end, should be included in each schedule	PMI 2007
16	Verification of Project Performance	Generated S-Curve should be in compliance with typical S-curves	De La Garza 1988

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17	Phase Duration	Each phase duration (Engineering, procurement, etc) should be in compliance with historical average data according to Total Installed Cost	Madl 2010
18	Phase Overlap	Engineering should not overlap construction by more than a certain percentage	Madl 2010
19	Calendar Verification	Non-working days should be indicated in the project calendar	Douglas 2009, Li & Carter, 2005
20	Working Hours Schedule Estimate Compliance	Basis of scheduling should be in compliance with basis of estimate as regards working hours	Madl 2010
21	Congestion Index (labor density)	Maximum number of workers per square meter should be limited to avoid congestion (25 to 30 sq.m/man) (200sqf/person)	Russell and Udairpurwala 2000, Bent and Humphreys1996, Kerridge and Vervakin 1986

Table 1. contd.

Schedule Assessment And Evaluation Criteria Evaluating how good a schedule is			
NO	Element	Explanation	Source reference
2.2 Schedule Components			
2.2.2 Critical Path			
22	Critical Path	Each critical activity should have a predecessor reflecting a physical dependency	O'Brien and Plotnick 2010
23.1	Schedule Criticality rate.1	Number of critical activities / total number of activities should be limited	O'Brien and Plotnick 2010, De La Garza 1988
23.2	Schedule Criticality rate.2	Duration of critical activities / total duration of activities should be limited	Spencer and Lewis 2006
24	Near criticality rate	Number of near critical activities / total number of activities should be limited (near critical activities: TF<5 to 10)	O'Brien and Plotnick 2010
25	Project Effort Ratio	Project critical path effort (number of labourers) / total project effort should be within a reasonable range	Spencer and Lewis 2006
26	Project Cost Ratio	Project critical path cost/ total project cost should be within a reasonable range	De la Garza 1988

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27	Critical Activity Duration	Critical activities, to be well manageable, should have a limited duration	De la Garza 1988
2.2.3 Resources			
28	Resource Loading	Schedule should be loaded with resources as much as possible	Madl 2010, Griffith 2005, Glenwright 2004, Zack 1991
29	Responsibility Assignment	A responsible party/person should be assigned to each activity	PMI 2007, De la Garza 1988
30	Schedule Leveling	Schedule should be levelled	GAO 2009, Douglas 2009b
31	Trades' Peak Resource Loading	Compliance of peak resource loading of each trade with historical average data according to total installed cost and phase duration	Madl 2010
32	Trades' Peak Resource Loading Relation	The relationship between various trades' peak resource loading should follow the historical average trend according to total installed cost and phase duration	Madl 2010
33	Trades' Rate of completion per week	Compliance of each trade's progress curve with historical (typical) average Data according to total installed cost and phase duration	Madl 2010

Table 1. contd.

Schedule Assessment And Evaluation Criteria Evaluating how good a schedule is			
NO	Element	Explanation	Source reference
2.2 Schedule Components			
2.2.3 Resources			
34	Peak to average labour ratio	Peak to average number of labourers for each trade should comply with the average historical data according to total installed cost and phase duration	Madl 2010
2.2.4 Special Considerations			
35	Permits & Environmental Remediation	Permits & environmental remediation should be included in the schedule (if applicable)	Nabros 1994, De La Garza 1988
36	Start-up and Testing Activities	Start-up and testing activities should be included in the schedule (if applicable)	Douglas 2009b, Zack 1991
37	Submittal Activities	Material and/or methods requiring prior	De la Garza 1988

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		approval must have their submittal activities in the network	
38	Submittals Review Activities	Submittal reviews to be reflected in schedule as an activity	Fredlund and king 1992, Zack 1991, De La Garza 1988
39	Procurement Activities	Procurement activities should precede special installation tasks	De la Garza 1988
2.2.5 Activity Attributes			
40	Number of Constraints	Number of constraints on activities start and finish should be limited	GAO 2009, Spencer and Lewis 2006, Dzeng et al. 2005
41	Lag Duration	Should not be greater than the duration of Predecessor or Successor activity	Winter 2010
42	Relationship Ratio	Total number of relationships/Total number of activities, should be limited	O'Brien and Plotnick 2010, Spencer and Lewis 2006
43	Activity without Affiliation	No open ended activity is allowed (activity without predecessor or successor)	Madl 2010, Li 2005, Winter 2010, Berg et al. 2009
44	Number of Activities	If number of activities has not been indicated in the contract, it has to be within a min/max range	O'Brien and Plotnick 2010, De La Garza 1988
45	Activity Float	Activities with excessive Total Float should be avoided	Li 2005, Dzeng et al. 2005, Berg et al. 2009, De La Garza 1988

Table 1. contd.

Schedule Assessment And Evaluation Criteria Evaluating how good a schedule is			
NO	Element	Explanation	Source reference
2.2 Schedule Components			
2.2.5 Activity Attributes			
46	Negative Float	No activity with negative float is allowed	Madl 2010, GAO 2009, Berg et al. 2009, Winter 2008
47	Weather Sensitive Activities	Special measures should be taken for this type of activities (e.g., Adjusting productivity according to seasonal conditions)	Douglas 2007, Li 2005, Dzeng 2004, De La Garza 1988
48	Activity Duration (rules of thumb)	Activity duration should be limited to certain Days	Berg et al. 2009, PMI 2007, De La Garza 1988

Source: Moosavi, (2012).

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Table 1 is an output of a checklist developed in Moosavi, (2012), based on the integration of sporadic knowledge encompassing a wide range of recommended schedule evaluation provisions. The extracted criteria from literature could be divided into two main categories: (1) conceptual and (2) quantitative provisions, (Moosavi, 2012).

The conceptual criteria reflect best practice recommended for consideration in evaluating schedules. They are usually generic and are provisions without adequate level of detail. Therefore, they are not sufficient for an effective method of schedule assessment, which requires more straightforward definite provisions. In order to remedy this deficiency, Moosavi, (2012) suggests that the generic best practices should be replaced by more detailed definite provisions in order to overcome the above deficiency. For instance, in the GAO guideline (2009), a provision recommends the critical path to be identified. This recommended practice, although extremely important, is very generic, and was thus replaced by the following, more specific criteria.

- All activities on the critical path should have a predecessor representing a physical dependency (O'Brien and Plotnick 2010).
- The criticality and near criticality rate should satisfy the defined thresholds, (O'Brien and Plotnick 2010, De La Garza 1988).
- Critical activities, to be well manageable, should have a limited duration, (De La Garza 1988).

There are other deficiencies associated with the application of these conceptual provisions. These criteria cannot be readily assessed, and the assessment of schedules merely based on conceptual provisions would always be susceptible to subjectivity. It is not uncommon for different schedule reviewers to conclude with different, even contradictory, review results. One solution to overcome these limitations could be defining the proposed conceptual criteria in the clearest possible way to mitigate the possibility of misinterpretation. Furthermore, it would be recommended to include both conceptual provisions and quantitative criteria to decrease the level of subjectivity of the process of schedule evaluation. Both of these proposed solutions were implemented in the present research in which both conceptual provisions and quantitative criteria are considered to decrease the level of subjectivity as argued.

The quantitative criteria are comprised of empirical rules and in some cases rules of thumb, introducing a set of thresholds on quantitative schedule components or items that should be included in the schedule. The quantitative schedule components encompass total float, duration, criticality and near criticality rate, project cost and effort ratio, and so forth. These provisions are also known as "schedule health metrics" (Berg, et al. 2009). The quantitative criteria are suitable for methods which include computer implementation, as these provisions can be the object of effective evaluation automation. The required time for assessing schedules based on these criteria is much shorter in comparison with conceptual provisions. In addition, the obtained results are objective, not subjective. However, quantitative evaluation criteria are mostly applicable for schedule health assessments. In fact, issues such as representativeness, completeness and job logic discussed in Booth, (1993) and Booth, et al. (1989), cannot be effectively assessed by the application of these criteria. Hence, schedule health metrics should be judicious; otherwise, they are merely meaningless numbers. Considering the advantages of

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quantitative criteria, a careful selection of widely accepted schedule health metrics was included in Moosavi, (2012). It is interesting to indicate that a considerable number of the selected provisions were repeated in different references cited in Moosavi, (2012). This could be considered as an indicator of consensus among experts in this domain of schedule assessment and schedule evaluation. A typical schedule assessment and evaluation reports is presented in Appendix 1. It illustrates the content of such an assessment of a schedule of a Project duration = 1004 days, Total number of activities = 141, Total number of critical activities = 41. Further, the assessment shows that the schedule is not loaded with resources and cost. Total number of constraints = 2

Total number of relationships = 244, Number of open ended activities = 3, Standard deviation of activities duration = 41, Criticality rate (duration of activities) = 14%, Criticality rate (number of activities) = 29%, Near criticality rate = 4%. The importance of type of evaluation is that it provides a basis for assessing the performance of two projects which have different total number of constraints applied, etc.

CONCLUSION

The paper concludes that just as the Quantity Surveyors does detail tender analysis and tender evaluation before recommending a contractor for award, now that the construction schedule may soon become a contract document in Nigeria, Quantity Surveyors should develop competencies to be able to evaluate the contractor’s schedule and recommend appropriate contractor for the award. This, as demonstrated in the paper will ensure cost effectiveness of the construction project process. The paper clearly show that both conceptual and quantitative evaluation provisions are key to obtaining results which are objective.

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APPENDIX

APPENDIX 1: TYPICAL SCHEDULE ASSESSMENT AND EVALUATION REPORTS
Project Name: A
General Information
Project duration = 1004 days
Total number of activities = 141
Total number of critical activities = 41
Maximum suggested activity duration = 90 Days
Total number of activities with out of range duration = 24
Maximum suggested critical activity duration = 30 Days
Total number of critical activities with excessive duration = 18
Total number of constraints = 2
Total number of relationships = 244
Relationship per activity = 1.73
Number of open ended activities = 3
Standard deviation of activities duration = 41
Criticality rate (duration of activities) = 14%
Criticality rate (number of activities) = 29%
Near criticality rate = 4%
Total number of activities with excessive total float = 47
Total number of activities with negative total float = 0
This schedule is not loaded with resources
This schedule is not loaded with cost

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