Benchmarking Reported Schedules using GAO's Schedule Assessment Guide Best Practices

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ABSTRACT

Oman power and water sector is developing with a continuous increasing demand of electricity and water. Currently, the project companies are delayed in delivering these project on time. The author suggest that quality of project schedule plays a crucial role in project delivery which can be improved. Using Multi Attribute Decision Making and GAO Schedule Assessment Guide, a scoring model was developed to quality check the reported schedules. The outcomes from the scoring model will be displayed on a scorecard using scores for each of ten best practices and four scheduling characteristics. A set of recommendations were provided to the management regarding the use of the scoring model as monitoring tool , modifications to the contracts, and the use of scorecard to communicate the results to project companies.

Key Words: GAO Schedule Assessment Guide, Oman Power and Water Procurement Company (OPWP), Multi- Attributes Decision Making (MADM), Project Management, Triple Constrains

INTRODUCTION

Delivering the project with in the triple constrains (cost, quality & time) is what every management is looking for. It is generally understood that any changes in any of these constrains will at least affect the other ones. Therefore, monitoring and controlling a project can be difficult depending on the complexity of the project. The one document that can capture all the information is the "Schedule". The durations and time sequence for all the activities are provided within the schedule on the basis to achieve the key milestones. Therefore, "the schedule not only a road map for project execution but also a tool to gauge the project progress and identify potential problems" [1]at early stages of the project.[2]

Being the client/buyer to independent water and power projects, it is important to deliver the project within the timeframe specified and within budget allocated to ensure reliable operation for more than 15 years. Currently, water and power are important and essential resources for day to day demands. However, the projects not only being delayed but also delivered with reliability and safety problems which directly affects the end-users. A root cause analysis was conducted by the team and the causes identified were, among other causes, lack of resources, lack of quality control and unrealistic project duration which consequently leads to poor scheduling and reporting. Therefore, a benchmark needs to be set in order to evaluate the current reported schedules by power generators or water producers.

[1] GAO, *GAO Schedule Assessment Guide: Best Practices for Project Schedules*
[2] Ibid

The GAO's schedule assessment guide provides best ten practices that helps managers to determine the health of the schedule. This assessment was developed by the U.S. Government Accountability Office[3] to address project delivery issues which includes project time delays and over budget specifically for projects that are funded by the government. The GAO's schedule assessment guide suggests that four characteristics should considered for high quality and reliable schedule which are:

- **Comprehensive:** The schedule should include all the activities required to achieve the deliverables in work break down structure (WBS). It should also include the information about the required recourses as well as the durations for each activity.
- **Well structured:** The activities should be logically sequenced, critical path should identified and reasonable total float should be included. Unusual or unreasonable information should justified.
- **Credible:** The schedule should be horizontally traceable to reflect the order of activities to achieve specific outcomes. It should also be vertically traceable to reflect the activities required to achieve certain milestone.
- **Controlled:** Using the actual progress from the site and logic the schedule should be updated. Then, the current reported schedule should be compared to the baseline schedule.

To achieve these four characteristics, the implementation of the GAO best ten practices is required. The table below summarizes how scheduling characteristics and best practices are related.

Scheduling Characteristics	Best Practices
Comprehensive	1. Capturing all activities 3. Assigning resources to all activities 4. Establishing the durations of all activities
Well structured	2. Sequencing all activities 6. Confirming the critical path 7. Ensuring reasonable float
Credible	5. Verifying that the schedule can be traced horizontally and vertically 8. Conducting a schedule risk analysis
Controlled	9. Updating the schedule using actual progress and logic. 10. Maintaining a baseline schedule

Figure 1: GAO Scheduling Charaterstics and Best Practices.[4]

Therefore, this paper will emphasis on the four characteristics as well as the ten best practices through the development of scoring model which then to be used:

[3] Ibid
[4] Formatted By Author

- As a tool to assess the reported schedule from the project companies.
- To modify our contracts to incorporate all the information needed.
- To provide feedback to project companies regarding their scores.

The paper will begin by developing the scoring model template by identifying the most appropriate multi-attributes decision making approach. The best ten practices, then, will need to be reviewed in order to demonstrate the benchmarks we are using. Finally, a case study was randomly selected to be benchmarked against the scoring model. Based on the results, recommendations will be presented to the management alongside with proper schedule management and control plan.

PROBLEM STATEMENT

On-time, on-budget, goal based project is what every stakeholder is looking for. Although it seems easy to manage these three objectives, it is a difficult task if a proper management plan is not provided. Currently, independent water and power projects face the problem of being delayed, over budgeted and end up with a considerable amount of deviations for the original scope. Although, the project managers alongside with their project engineers and consultants efforts are massive, but it is still not effective.

Consequently, a detailed analysis of causes of the delays led to insufficient information being provided from the project companies which basically led to ineffective project management i.e. estimating the delays. Moreover, the power or water purchase agreement (contract between OPWP and project companies) does not include enough details as to what information company shall provide. Since these projects are built on demand basis, any delay in delivering the project on time, it will affect the public community by not providing them with water and/or electricity. This means shortage of water on national level, and/or load shedding where electricity is being cut off in some areas.

Furthermore, the water and power projects are being funded by government indirectly where OPWP acts as the only buyer of electricity and water. Therefore, any delays or change requests will indirectly affects the public money and the company image on its reliability and ability to deliver the project as contracted. However, solving this problem requires a huge effort, coordination and cooperation from all stakeholders at least to collect the required information to come up with a strategy that helps project delivery. Currently, through this research paper, the submitted reports/ schedules will allow us to determine what information to include in our contracts for the coming projects.

METHODOLOGY

In order to create a scoring model, a scoring method needs to be selected in order to ensure that the resulted scores are reliable enough to take critical decision. The Guild of Project Controls Compendium and Reference suggests two methods for Multi Attributes Decision Making

(MADM).[5] Therefore, these two methods will be used to develop a scoring model which will help us to rate how healthy the schedule is. These methods are:

- **Non- compensatory approach** is effective when we are looking for specific features/ attributes. But this will rule out all other features whether they are relevant to assessment or not. In other words, non-compensatory does not trade-off a low value on one criterion against a high value on another attribute.
- **Compensatory approach,** in the other hand, will compensate for all the features, therefore, this is effective to account for all features. This approach balances a low value on some criterion against a high value on another criterion.[6]

In order to select the best method, at least the following criteria need to be met:

- "Can it be built in excel spreadsheet?" This is an important question in which limit my decision to the available resources. A method that is not within the company resources can cost money thus not favorable to the management.
- "Account for all features?" Since we are using GAO Schedule Assessment Guide, multiple features need to be accounted for when scoring a specific schedule.
- "How score is calculated?" This will help to identify the best way to present the results to the management.
- "Can it include GAO assessment (ten best practices)?" A mandatory requirement in order to build the scoring model.
- "Can it provide rating?" Providing rating can help to see how much improvement is needed

	Importance	Compensatory		Non-compensatory	
Acceptance Criteria	A	B	A*B	C	C*A
Can it be built on excel spreadsheet?	2	4	8	4	8
Account for all features?	2	4	8	2	4
Provides Weighted score?	3	4	12	2	6
GAO best practices?	3	4	12	4	12
Rating results?	1	3	3	2	2
		Total	43	**Total**	32

Figure 2: Compensatory and Non-compensatory models Against Acceptance Criteria[7]

Comparing the selected methods to the acceptance criteria using MDAM yields to compensatory approach to be the best option. However, there are two techniques under this approach which are:

[5] PP Admin. (2015). Multi- Attributes Decision. *Guild of Project Controls Compendium and References.*
[6] Gudigantala, N. (2014). A Study of the Compensatory and Non-Compensatory Decision. *Journal of Applied Business and Economics*. 16.
[7] By Author

- **Non-Dimensional Scaling Technique**: this technique is simple where the decision maker only chooses the alternative with largest number of positive attributes and does not account for the other attributes.

- **Additive Weighting Technique:** The decision made here will takes into account the relative importance of the positive rated attributes by multiplying the alternative rates by the importance weights.[8]

The acceptance criteria here is basically the same one used above except that now I looking which technique is best at giving the accurate score:

	Importance Scale	Non-Dimensional Scaling		Additive Weighting	
Acceptance Criteria	**A**	**B**	**A*B**	**C**	**A*C**
Excel spreadsheet based	1	3	3	3	3
GAO best practices included	5	3	15	3	15
Accounts for all attributes	3	3	9	3	9
Accounts for the importance of attributes	4	1	4	3	12
Ratio scale measurement	2	2	4	3	6
		Total	35	**Total**	45

Figure 3: Non- Dimensional Scaling and Additive Weighting Methods against Acceptance Criteria[9]

Now we know the best approach to score the reported schedule (Additive weighting under the compensatory model). The scoring model will use three GAO quality checks which are:

- Ten best practices checklist
- Appendix II
- Appendix IV

Many similarities can be found in these three quality checks. Therefore, I will need to combine all three checks by eliminating similarities and provide one list of quality check. Another problem is come up with weighting score in which each item in the list will contribute to each one of ten best practices. Then, will calculate the weighting score contributing to the final score at which we judge the health of schedule. Basically, the score will be assigned based on the number items under each practice. However, the score for each item will be based on quantitative measure, similar to those listed in Appendix IV of GAO Schedule Assessment Guide. For example:

[8] Abdullah, L. & Adawiyah, R. (2014). Simple Additive Weighting Methods of Multi criteria Decision Making and Applications: A Decade Review. *International Journal of Information Processing and Management (IJIPM).* Volume 5.
[9] By Author

SN	Best Practices	Items	Contribution
1	*Capturing All Activities*	9.00	13.24%
2	*Sequencing All Activities*	8.00	11.76%
3	*Assigning Resources to All Activities*	4.00	5.88%
4	*Establishing the Duration of All Activities*	4.00	5.88%
5	*Verifying That the Schedule Can Be Traced Horizontally and Vertically*	3.00	4.41%
6	*Confirming That the Critical Path Is Valid*	4.00	5.88%
7	*Ensuring Reasonable Total Float*	5.00	7.35%
8	*Conducting a Schedule Risk Analysis*	7.00	10.29%
9	*Updating the Schedule Using Actual Progress and Logic*	12.00	17.65%
10	*Maintain a Baseline Schedule*	12.00	17.65%
	Total	68.00	**100.00%**

Figure 4: Ten Best Practices Score Weightages.[10]

As mentioned above, the GAO Schedule Assessment Guide focuses on four to ensure reliable schedule. Therefore, we need a scorecard that rate the schedule within these characteristics:

Scheduling Characteristics	Best Practices	Items	Contribution	Total
Comprehensive	1. Capturing all activities	9	52.94%	25.00%
	3. Assigning resources to all activities	4	23.53%	
	4. Establishing the durations of all activities	4	23.53%	
Well structured	2. Sequencing all activities	8	47.06%	25.00%
	6. Confirming the critical path is valid	4	23.53%	
	7. Ensuring reasonable float	5	29.41%	
Credible	5. Verifying that the schedule can be traced horizontally and vertically	3	30.00%	14.71%
	8. Conducting a schedule risk analysis	7	70.00%	
Controlled	9. Updating the schedule using actual progress and logic.	12	50.00%	35.29%
	10. Maintaining a baseline schedule	12	50.00%	

Figure 5: Scheduling Characteristics Score Weightages.[11]

[10] By Author

So far we identify the appropriate scoring model, the weight contributing for each practice and the scorecard that allows us to assess where the strength and weakness of the schedule. Now we can show the score template that can be used to evaluate each schedule.

Basically the schedule will contain the ten best practices along with quality items that we combined from checklist, Appendix II and Appendix IV from GAO Assessment Guide. For each item a formula is used to calculate the percent achievement, which then will be compared against the acceptance requirement. The last column then will include the contributing weightage that is used to calculate final score.

[11] By Author

SN	Quality Check	Formula	Acceptance Requirements	Contribution to Score
1	*Capturing All Activities*			13.24%
1.1	Does the Schedule include all specified key milestones in Contact?	(Contractual milestone in Schedule)/ (Contractual Milestone in Contract)	All Contractual Milestones shall be included in the Schedule	11.11%
1.2	Does the Schedule include all steps, events, outcomes to Accomplish deliverables?	Yes/No	At least 100% shall be accomplished	11.11%
1.3	Does Schedule include all efforts External and internal interfaces?	(interfaces milestones)/(interfaces)	All interfaces shall be included	11.11%
1.4	Does the Schedule Include all activities and deliverables required by interfaces?	(permits+ testing +signals)	minimum of 100% on interfaces activities should be included	11.11%
1.5	Does the schedule include detailed activities and milestones required to achieve deliverables?	(# detailed activities/milestones)/(Deliv erables)	minimum of 100% achievement	11.11%
1.6	Does Activities starts with "Verb"?	(activities with descriptive name)/(all activities)	minimum of 100% achievement	11.11%
1.7	Can the activities be easily traced (i.e. activity codes)?	(activities with codes)/ (total activities) Proper coding?	Each activities shall has unique ID	11.11%
1.8	Does all activities includes planning (i.e. start and finish dates)?	(activities with start and finish dates)/(all activities)	Minimum 100% achievement	11.11%
1.9	Is the schedule provided include summary activities?	(summary activities) / (total activities)	minimum 100% achievement	11.11%
2	*Sequencing All Activities*			11.76%
3	*Assigning Resources to All Activities*			5.88%
4	*Establishing the Duration of All Activities*			5.88%
5	*Verifying That the Schedule Can Be Traced Horizontally and Vertically*			4.41%
6	*Confirming That the Critical Path Is Valid*			5.88%
7	*Ensuring Reasonable Total Float*			7.35%
8	*Conducting a Schedule Risk Analysis*			10.29%
9	*Updating the Schedule Using Actual Progress and Logic*			17.65%
10	*Maintain a Baseline Schedule*			17.65%

Figure 6: Template of Scoring Model.[12]

[12] By Author

Now, for this template to work, we need to gather the required information which are:

- Reported schedule in primavera software or
- Reported schedule in MS project software
- Contract documents
- Other agreed documents (i.e. amendments to contract)

The reported schedules will need to be exported to excel file in order to calculate the score. Then based on this score the management should have the right to reject or accept the schedule, and provide a feedback to project company in order to improve the schedule.

FINDINGS

Due to the lack of schedules being reported on the recommended software above, it was not possible to do the analysis on the old project. Another factor is the time where more time need to be allocated to evaluate each schedule. With available resource, one case study was selected in order to show the management the importance of this research paper, and allow to do more analysis to other projects and see the correlation to the delays.

Case Study: Independent Power Project

This project is an electricity generation company. Basically project implementation department is monitoring the project during construction and commissioning stages until the handover to the operation team. One tool of monitoring the project is doing a quantitative and qualitative analysis through the monthly reports. This schedule consists of 3427 activities and 267 milestones. The following table shows how this project was evaluated.

Best Practices	Score
Capturing All Activities	71.11%
Sequencing All Activities	86.25%
Assigning Resources to All Activities	0.00%
Establishing the Duration of All Activities	66.09%
Verifying That the Schedule Can Be Traced Horizontally and Vertically	66.67%
Confirming That the Critical Path Is Valid	60.00%
Ensuring Reasonable Total Float	44.00%
Conducting a Schedule Risk Analysis	21.43%
Updating the Schedule Using Actual Progress and Logic	38.33%
Maintain a Baseline Schedule	25.00%

Figure 7: Case Study 1 Best Practices Scores[13]

[13] By Author

Current required schedule level is level 3 as per the contract. However, we faced many problems in which we sometime required level 4 or even level 5 schedule in order to do our analysis properly. Therefore, I suggest a passing score of 100% (subject to management approval) to accept the submitted schedule. I choose 100% because majority of items in ten practices will be met and so will be enough for us to do our schedule analysis. This schedule has a score or 46.53% which is really poor compare to our passing score. However, it is important to look in more details:

A. **"Capturing all activities":** The schedule score its best score in meeting this practice. It included the contractual milestones and start and finish dates for all activities. The interface activities were partially met the requirement where some important interfaces were missing from the schedule such as interface with ministry of environmental and climate affairs. However, the activities in schedule were not coded properly and were not provide with descriptive name.

B. **"Sequencing all activities":** All activities have logic links and the majority represent F-S links. Moreover, 14% (483 activities) of the activities have lags time, and 1.1% (38 activities) have lead time. Overall, this section meets the passing score criteria, however, an improvement in interfaces logics is needed. The schedule only present the interface activities as constrained dates but with no detail description on how to meet it.

C. **"Assigning resources to all activities":** the schedule did poorly in this section where no resources where assigned to activities. However, the management should decide whether to include this practice in our analysis to the project companies.

D. **"Establishing durations of all activities":** Here the score was low because the durations were not with the same units (i.e. days, weeks) and it took a long time to make the data at same units. Moreover, about 1221 activities have durations greater than the reporting period which is impossible for us to measure the progress of these activities.

E. **"Verifying that the schedule can be traced horizontally and vertically":** Although not meeting the passing criteria, the schedule clearly identified the major deliverables and it can roll up the detail activities to summary activities and eventually to WBS level. The schedule, however, does not include givers and receivers of the milestones which would be highly beneficial for record and verifications purposes.

F. **"Confirming the critical path is valid":** The schedule contains one column that specifies whether a specific activity is critical or not. Basically most of the late finish activities are identified as critical and the key milestone derives the detail activities. However, it not shown how the management approach these activities and critical activities are still under constrained dates and includes lags.

G. **"Ensuring reasonable float":** The project company provided an appendix to the report that includes activities with less than 3 days float. However, the schedule represent

milestones with excess total and free float (i.e. 600 days). This caused the company problem in forecasting delay of the project because the float is not identified to each activity so it can monitored closely.

H. **"Conducting a schedule risk analysis":** the schedule has one column for likely duration as risk analysis. Moreover, most of this analysis is attached to the report as "Project risk analysis" where the risk is identified along with mitigation and action plan. However, the near critical path items, contingencies, worst case scenario and probability of meeting the milestones are not identified within the document.

I. **"Updating the schedule using actual progress and logic":** The reported schedule is being updated periodically by the project company and the last update date can easily be found. However, changing logics is not known as there is no documents that lists these changes with justifications.

J. **"Maintaining a baseline schedule":** although the baseline schedule document exits and followed, it does not include the requirement needed under GAO Schedule Assessment Guide (i.e. schedule change management process)

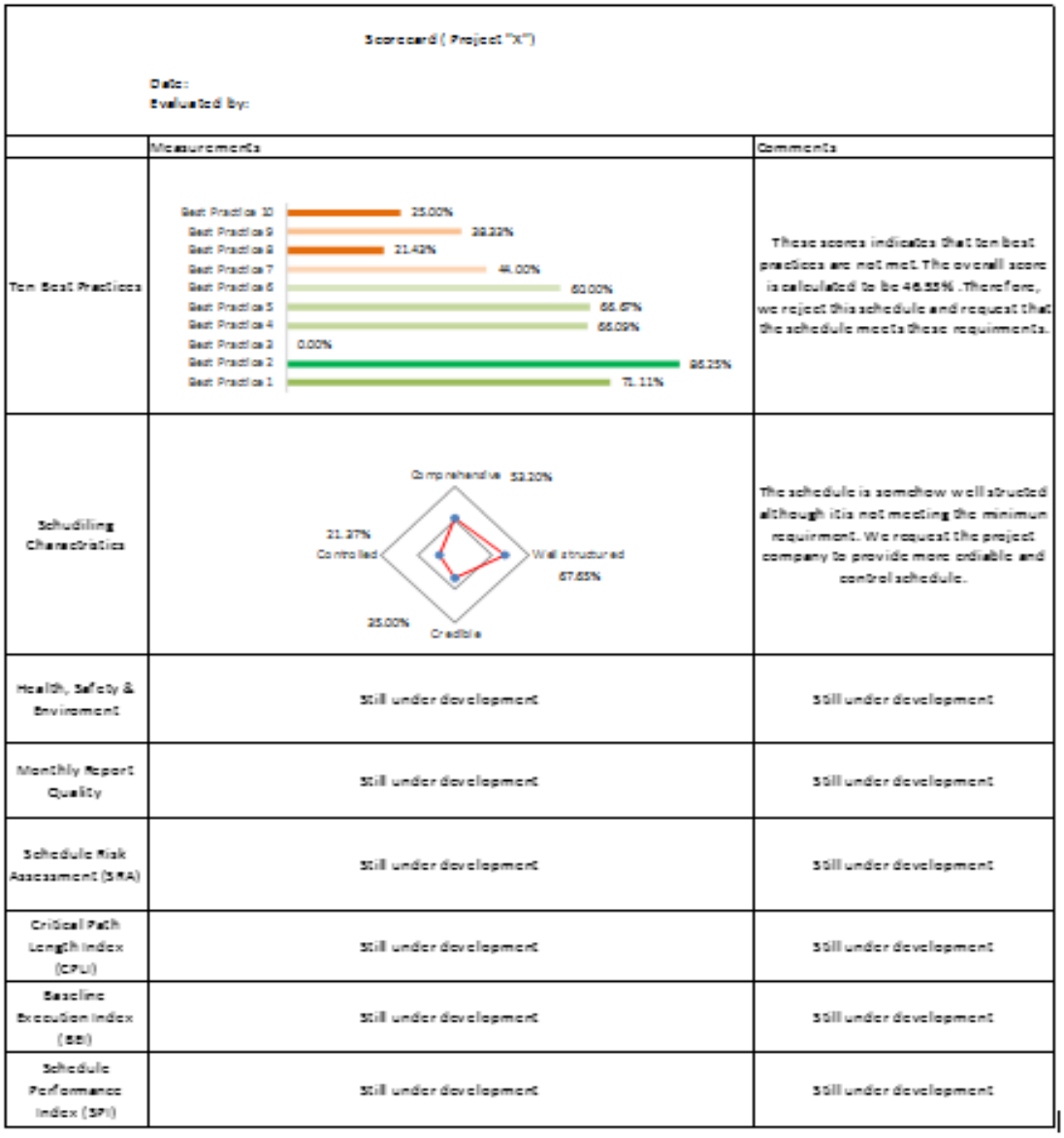
Scheduling Characteristics	Score
Comprehensive	53.20%
Well structured	67.65%
Credible	35.00%
Controlled	21.37%

Figure 8: Case Study 1 Scheduling Characteristics Scores[14]

The above table suggests that the schedule partially met the criteria of GAO Schedule Assessment but it did not meet the minimum acceptance criteria (100%). We can see that the schedule is somehow well-structured, and comprehensive. Therefore, from quantitative point of view, the schedule is doing fairly well but not very good. Now, when we look at the qualitative point of view (which is really important), it seems doing really poor and tells us that the company is not paying very good attention to schedule.

After we evaluated the schedule, these data should be communicated to Project Company in a scorecard. It is possible to include other things such as HSE performance, Monthly report quality and Schedule Analysis. A Typical template for scorecard is:

[14] By Author



Scorecard (Project "X")

Date:
Evaluated by:

	Measurements	Comments
Ten Best Practices	Best Practice 10 25.00%; Best Practice 9 28.22%; Best Practice 8 21.42%; Best Practice 7 44.00%; Best Practice 6 60.00%; Best Practice 5 66.67%; Best Practice 4 66.09%; Best Practice 3 0.00%; Best Practice 2 96.25%; Best Practice 1 71.11%	These scores indicates that ten best practices are not met. The overall score is calculated to be 46.55% .Therefore, we reject this schedule and request that the schedule meets these requirments.
Scheduling Characteristics	Comprehensive 53.20%; Well structured 67.65%; Credible 25.00%; Controlled 21.27%	The schedule is somehow well structed although it is not meeting the minimun requirment. We request the project company to provide more ordiable and control schedule.
Health, Safety & Environment	Still under development	Still under development
Monthly Report Quality	Still under development	Still under development
Schedule Risk Assessment (SRA)	Still under development	Still under development
Critical Path Length Index (CPLI)	Still under development	Still under development
Baseline Execution Index (BEI)	Still under development	Still under development
Schedule Performance Index (SPI)	Still under development	Still under development

Figure 9: Template of Scorecard[15]

CONCLUSIONS

With current emerging delays in power and water independent project, OPWP as only buyer of electricity and water needs to monitor these project closely and deliver to the customer what it promises. One example of monitoring tool is the project schedule. The purpose of this research paper was to achieve the following:

1. Develop a scoring model to assess the reported schedule from the project companies.
2. Modify contracts to incorporate all the information needed to use the scoring model.

[15] By Author

3. Provide feedback to project companies regarding their scores through scorecard.

The paper addresses the first point by using GAO' ten best practices of a schedule. The model then was developed by assigning appropriate weightages using MADM method. Using both Appendix II and Appendix IV of the GAO's Schedule Assessment Guide to develop the scoring model together with MADM method, the scoring sheet was created as shown in Table 5. The model will provide vertical and horizontal scoring where it will enable us to look to causes for having a low score or high score. Currently, we are considering a minimum acceptance criteria of 100% achievement as a way to push the project companies to incorporate all GAO's best practices.

The company (OPWP) now needs to consider some modifications to the contracts to make sure that all the information to provide high quality schedule. one modification should be to increase the level of the reported schedule from level 3 to at least level 4 to allow the engineers to do a detailed schedule analysis thus identify the risks and delays at early stages of the project where they can be mitigated. Another modification is to add a clause that requires the project companies to use GAO Schedule Assessment Guide to quality check their schedule.

Finally, each project manager will need to communicate the scores on the schedule to the project company. Obviously, we cannot share the scoring model with project company, therefore, a scorecard was developed. The scorecard as shown in Figure 1, where the results are presented in graphs along with comments and actions that project company shall do or improve. This scorecard is still under development, where other measurement can be included.

To conclude, OPWP management should consider the above mentioned points as soon as possible. The implementation of this research might take time as the current contracts does not include the required modifications. Having a scoring model along with score card will allow the project managers to easily present these data to management on monthly basis. With project delays can be minimize and OPWP will have more comfort with reported information from Project Companies.

FOLLOW ON RESEARCH

The next step is do this analysis on the other projects and discuss with project managers the findings. Then, based on their decision, training other team members to do this analysis to their projects. The project implantation director is then need to approve this scoring model and recommend the required modifications to the management.

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Appendix I: An Auditor's Key Questions and Documents

Best Practice 1: Capturing All Activities

Key Questions

1. Is there an IMS for managing the entire program (not just a block, increment, or prime contractor)? Is the schedule defined at an appropriate level to ensure effective management?
2. Is the IMS maintained in scheduling software and linked to external detailed subproject schedules? Do the government program management office and contractors have different scheduling software systems? If so, how is integrity preserved and verified when converting the schedule?
3. Does the IMS include government, contractor, and applicable subcontractor effort?
4. Does the schedule reflect the program WBS and does the WBS enable the tracking of key deliverables? Does every activity trace to an appropriate WBS element, and do the activities define how the deliverables will be produced? Is there a WBS dictionary?
5. Are key milestones identified and are they consistent with the contract dates and other key dates established by management in the baseline schedule?
6. Are clear start and finish milestones present in the schedule? Are there too many milestones in relation to detail activities?
7. Are all activities mapped to the contract statement of work (SOW) or statement of objectives (SOO) to ensure that all effort is accounted for in the schedule? Are activities within the schedule easily traceable to key documents and other information through activity or task codes?
8. Are activity names unique and descriptive? Are activities phrased in verb-noun combinations (for example, "develop documentation")? Are milestones named with verb-noun or noun-verb combinations (for example, "start project" or "project finished")?
9. Are level-of-effort activities clearly marked? Are LOE activity durations determined by the activities they support?
10. Does the schedule include risk mitigation activities?

Key Documentation

1. Work breakdown structure (WBS), statement of work or objectives (SOW or SOO), and mission requirements
2. SOW or SOO crosswalk to the schedule WBS
3. Contractor WBS to program WBS crosswalk
4. Schedule custom fields and activity codes dictionary and LOE field identification
5. Activity codes used to organize and filter the activities into categories as necessary to confirm a complete scope of work

	6. Engineering plans used to define activities, such as systems engineering plan, software development plan, risk management plan, and master test plan. 7. Systems engineering life cycle, system development life cycle, or other required life cycle documentation 8. Enterprise architecture documentation for software programs
Likely Effects If Criteria Are Not Fully Met	1. If activities are missing from the schedule, then other best practices will not be met. If all necessary activities are not accounted for, it is uncertain whether all activities are scheduled in the correct order, resources are properly allocated, missing activities will appear on the critical path, or a schedule risk analysis can account for all risk. 2. Failing to include all work for all deliverables, regardless of whether the deliverables are the responsibility of the government or contractor, can lead to project members' difficulties because of an incomplete understanding of the plan and its progress toward a successful conclusion. 3. If the project schedule does not fully and accurately reflect the project, it will not be an appropriate basis for analyzing or measuring technical work accomplished and may result in unreliable completion dates, time extension requests, and delays. 4. If government work is not captured in the IMS, the program manager will be less able to plan all the work and minimize the risk of government-caused delays. 5. Because the schedule is used for coordination, missing elements will hinder coordination efforts, increasing the likelihood of disruption and delays. 6. If the schedule is not sufficiently detail planned, then opportunities for process improvement (for example, identifying redundant activities), what-if analysis, and risk mitigation will be missed. 7. LOE activities can interfere with the critical path unless they are clearly marked and represented as summary or hammock activities designed for the purpose. 8. Too many milestones in the schedule can mask the activities necessary to achieve key milestones and can prevent the proper recording of actual progress. 9. Schedules that are defined at too high a level may disguise risk that is inherent in lower-level activities. Conversely, schedules that have too much detail make it difficult to manage progress. 10. Unless the schedule is aligned to the program WBS, management cannot ensure that the total scope of work is accounted for within the schedule.

11. Repetitive naming of activities makes communication difficult between teams, particularly between team members who are responsible for updating and integrating multiple schedules.

Best Practice 2: Sequencing All Activities

Key Questions

1. Have the activities and logical relationships been determined by those executing the project?
2. Are the majority of the relationships within the detailed schedules finish-to-start?
3. Are there any dangling predecessors or successors?
   a. Does each activity (except the start milestone) have an F–S or S–S predecessor that drives its start date?
   b. Does each activity (except the finish milestone and deliverables that leave the project without subsequent impact on the project) have an F–S or F–F successor that it drives?
4. Do summary activities have predecessor or successor links?
5. Do activities have start-to-finish links?
6. How much convergence (that is, several parallel activities converging at one major event) is there in the schedule?
7. Does the schedule contain date constraints other than "as soon as possible"? Is each one justified in the schedule documentation?
8. Is the work of suppliers, government offices or agencies, or subcontractors represented in the schedule as an activity so that risk can be applied rather than representing the "promise date" as a date-constrained milestone?
9. Are lags or leads specified between the activities? Can these be more accurately characterized by improving logic or adding activity detail?

Key Documentation

1. Justification for using hard and soft date constraints instead of activities' duration and logic
2. Justification for lags and leads instead of activities' duration and logic
3. Justification for any activity that has no F–S or S–S predecessor or no F–S or F–F successor

Likely Effects If Criteria Are Not Fully Met

1. The logical sequencing of events is directly related to float calculations and the critical path. If the schedule is missing dependencies or if activities are linked incorrectly, float estimates will be miscalculated. Incorrect float estimates may result in an invalid

critical path and, thus, will not be reliable indicators of where resources can be shifted to support delayed critical activities.

2. That all interdependencies between activities are identified is necessary for the schedule to properly calculate dates and predict changes in the future. Without the right linkages, activities that slip early in the schedule do not transmit delays to activities that should depend on them. When this happens, the schedule will not provide a sufficient basis for understanding the program as a whole, and users of the schedule will lack confidence in the dates and the critical path. Finally, when activities are not correctly linked, the program cannot use the IMS to identify disconnects or hidden opportunities and cannot otherwise promote efficiency and accuracy or control the program by comparing actual to planned progress.
3. Logical sequencing promotes a more realistic workflow. If missing, project team members can misunderstand one another, especially regarding receivables and deliverables.
4. The presence of "dangling activities" reduces the credibility of the calculated activity start and finish dates and the identity of the critical paths. The slip or elongation of an activity that has no logical successor will not reflect its effect on the scheduled start dates of successor activities.
   a. If an activity—other than the start milestone—does not have an F–S or S–S predecessor that drives its start date, the activity will start earlier if its duration is projected to be longer than originally believed. An earlier start may be illogical.
   b. If an activity—other than the finish milestone or deliverable that leaves the project—does not drive a successor by an F–S or F–F link, the implications of its running late or long are not passed on to any successor activity.
5. The ability of a schedule to forecast start and finish dates of activities and key events is directly related to the complexity and completeness of the schedule network. Unless complete network logic is established, the schedule cannot predict impacts on the project's planned finish date from, among other things, misallocated resources, delayed activities, external events, and unrealistic deadlines.
6. Because a logic relationship dictates the effect of an on-time, delayed, or accelerated activity on following activities, any missing logic relationship is potentially damaging to the entire network.
7. Path convergence issues can represent an unrealistic plan by implying that a large number of activities must be finished at the same time before a major event can occur as planned. An excess number of parallel relationships can indicate an overly aggressive or unrealistic schedule.

8. Hard date constraints that restrict activities to starting or finishing on a specific date must be justified by referring to some controlling event outside the schedule. Date constraints prevent activities from responding dynamically to network logic, including actual progress and availability of resources. They can seriously affect float calculations and the identification or continuity of the critical path and can mask actual progress or delays in the schedule.
9. Hard and soft constraints interfere with the results of a schedule risk analysis because they prevent activity dates within the schedule from dynamically responding to changes in predecessor dates.
10. A customer-mandated date is not a legitimate reason to constrain an activity. A schedule is intended to be a dynamic, pro-active planning and risk mitigation tool that models the project and can be used to track actual progress toward important project milestones. Schedules with constrained dates can portray an artificial or unrealistic view of the project plan.
11. Constraints should be used only when necessary and only if their justification is documented because they override network logic and restrict how planned dates respond to actual accomplished effort or resource availability. A large number of activities with constraints is typically a substitute for logic and can mean that the schedule is not well planned and may not be feasible.
12. SNLT and FNLT constraints prevent activities from starting or finishing later than planned, essentially restricting the ability of any predecessor delays to affect their start and finish dates.
13. Applying constraints to represent the availability of resources requires constant manual upkeep of the schedule.
14. Mandatory start and finish constraints are the most rigid of all constraints because they do not allow the activity either to take advantage of time savings by predecessor activities or to slip in response to delayed predecessors or longer-than-scheduled durations.
15. The time to produce an external product should be represented by a reference or schedule visibility activity rather than a constrained milestone representing receipt of the product. By modeling vendor or contractor production as an activity, the program office can track the contractor's high-level progress and apply risk to the external production activity.
16. Lags must be justified because they may represent work or a delay that may be variable while the lag is static. Lags should not be used to represent activities because they cannot be easily monitored or included in the risk assessment and do not take resources. Activities represented by lags are not, in fact, risk free.

17. Constantly updating lags manually defeats the purpose of a dynamic schedule and makes it particularly prone to error.
18. The use of a lag with F–S logic is generally not good practice because it is generally not necessary. In such cases, every effort should be made to break activities into smaller tasks and to identify realistic predecessors and successors so that logic interface points are clearly available for needed dependency assignments.
19. Leads are generally not valid. As negative lags, leads imply the unusual measurement of negative time and exact foresight about future events.
20. Lags are also often used as buffers for risk between two activities, but this practice should be discouraged because the lags persist even as the actual intended buffer is used up.

Best Practice 3: Assigning Resources to All Activities

Key Questions

1. What resources are specified and assigned to the activities? At what level of detail are resources specified (for example, labor categories, organizations, or individual names)?
2. Are significant material and equipment resources captured in the schedule?
3. Do the resources have logical resource calendars?
4. How were resource estimates developed for each activity?
5. Has analysis been performed to ensure that resources are sufficient and available in each work period when needed?
   a. Are there potential difficulties in obtaining scarce resources to accomplish the work?
   b. Are there work periods for which more resources are required than are available? What is the plan for resolving resource deficiencies?
6. Has resource leveling been performed?
7. To what extent are the resource estimates in the schedule consistent with those in the project cost estimate?

Key Documentation

1. Basis of estimates for resource assumptions should align with resource estimates within the cost estimates.
2. A resource allocation planning document should define resource profiles and tables for unique resources derived from the schedule.
3. Resource output from scheduling software across all project schedules should be reported. This highlights the problem of

assigning resources to several schedules in parallel. It also catches any issues with the resource leveling assumptions that the software is using and the use of "placeholder" resource names.

Likely Effects If Criteria Are Not Fully Met

1. Information on resource needs and availability in each work period assists the program office in forecasting the likelihood that activities will be completed as scheduled. If the current schedule does not allow insight into current or projected allocation of resources, then the risk of the program's slipping is significantly increased. Overallocated resources result in inefficiency (for example, staff are less productive because of extended overtime) or project delay from unavailable resources.
2. Resources must be considered when creating a schedule because their availability directly affects an activity's duration.
3. A schedule without resources implies an unlimited number of resources and their unlimited availability.
4. If there is no justification for allocating and assigning resources, the schedule will convey a false level of accuracy.
5. Bow waves in forecasts of resource assignments represent the need for large amounts of resources near the end of work streams to finish deferred or delayed work on time. Often the number of resources and funding required at the peak of the bow wave are unrealistic.
6. If resource leveling causes enormous delays in the project finish date—for example, by many months or years—then the original resource assumptions, network logic, or activity durations must be examined for pragmatism.
7. Automatic resource leveling can lead to inefficient output by delaying activities if only partial resources are available and preventing activities from being partially accomplished while waiting for the full complement of resources to become available.
8. Incorrect resource assumptions (usually in the form of unwarranted optimism) will lend unreasonable credence to a resource-leveled schedule, and the resulting leveled schedule will convey a false sense of precision and confidence to senior decision makers.
9. A schedule that has not reviewed and resolved resource utilization issues is not credible.
10. If the baseline schedule does not identify the planned resources, it cannot be used to make important management decisions, such as reallocating resources from activities with significant float to critical activities that are behind schedule.
11. If the schedule does not have resource assignments, management's ability to monitor crew productivity, allocate idle resources, monitor resource-constrained activities, and level resources across activities is severely limited.

Best Practice 4: Establishing Durations for All Activities

Key Questions	1. Were durations determined from work to be done and realistic assumptions about available resources, productivity, normal interferences and distractions, and reliance on others? 2. For a detailed schedule, are durations short enough to be consistent with the needs of effective planning and project execution? Are durations no more than two reporting periods for effective statusing and progress reporting of near-term work? Are activity durations too short? 3. Are activities long in duration because of LOE or rolling wave planning? 4. Were durations estimated by the person responsible for the activities or reviewed with experts who have experience with similar types of work? 5. Was the project duration determined by some target or mandated date? 6. Are durations based on appropriate calendars? Do any specific conditions necessitate special calendars, and are they addressed (for example, religious holidays, nonwork periods for climate, shift work, unavailability of resources)? Are activity durations assigned inconsistent time units?
Key Documentation	1. How durations of work activities were estimated is documented at the appropriate level of detail. For instance, the basis of estimate includes the assumptions made to justify the durations assumed for the cost. These should be consistent with the durations at the same level of detail. 2. Documentation justifies nonstandard working calendars. 3. Documentation justifies excessively long durations, including the identification of LOE activities and how they were scheduled.
Likely Effects If Criteria Are Not Fully Met	1. If activities are too long, the schedule may not have enough detail for effective progress measurement and reporting. 2. If activities are too short, the schedule may be too detailed. This may lead to excessive work in maintaining the logic, updating the status of activities, and managing the many short-duration activities. 3. When durations are not based on the effort required to complete an activity, the resources available, resource efficiency, and other factors

such as previous experience on similar activities, then there is little confidence in meeting the target deliverable date.

4. Schedules determined by imposed target completion dates rather than work and logic are often infeasible.
5. Durations estimated under optimal or "success-oriented" conditions will produce unrealistic project delivery dates and unreliable critical paths and could mask program or project risks.
6. Proper use of resource and task calendars will usually preclude the need for soft constraints in schedules. But improperly defined task or resource calendars will incorrectly represent the forecasted start, finish, and durations of planned activities.
7. The default calendar in a schedule software package rarely has appropriate national holidays defined as exceptions and will not have specific blackout periods or other project-specific exceptions defined.
8. Schedules will incorrectly represent the forecasted start, finish, and durations of planned work if resources are assigned to incorrect calendars. Ensuring realistic calendars will provide for more accurate dates and may reveal opportunities to advance the work.

Best Practice 5: Verifying That the Schedule Is Traceable Horizontally and Vertically

Key Questions

1. Is all logic in place and has the technical content of the schedule been validated?
2. Are major hand-offs and deliverables easily identified in the schedule? How are major hand-offs and deliverables negotiated and monitored?
3. Does the schedule have fields that record the responsible givers and receivers?
4. Are the key dates consistent between lower-level detailed working schedules and higher-level summary schedules? Do all lower-level activities roll up into higher WBS levels?
5. Do major milestones map between the schedule and management-level briefing charts?

Key Documentation

1. All representations of the schedule are given as of a specific time. These may include different levels of the same schedule used in presentations as well as schedule representation using different

	platforms (scheduling or presentation packages) for different audiences. 2. The integration between summary, intermediate, and detailed schedules is demonstrated.
Likely Effects If Criteria Are Not Fully Met	1. If the schedule is not horizontally traceable, there may be little confidence in the calculated dates or critical paths. Schedules that are not horizontally integrated may not depict relationships between different program elements and product handoffs. Any logic errors between summary, intermediate, and detailed schedules will cause inconsistent dates between schedules and will cause different expectations between management and activity owners. 2. Unless the schedule is horizontally traceable, activities whose durations are greatly extended will have no effect on key milestones. 3. Schedules that are not horizontally integrated may not depict relationships between different program elements and product hand-offs. When this happens, hand-offs of project subcomponents cannot be fully traced to the end product, leading to less effective project management. 4. Vertical traceability provides assurance that the representation of the schedule to different audiences is consistent and accurate. Without vertical traceability, there may be little confidence that all consumers of the schedule are getting the same correct schedule information. 5. Unless the schedule is vertically traceable, lower-level schedules will not be consistent with upper-level schedule milestones, affecting the integrity of the entire schedule and the ability of different teams to work to the same schedule expectations. 6. Without horizontal and vertical traceability, there is no valid critical path or computation of float.
Best Practice 6: Confirming That the Critical Path Is Valid	
Key Questions	1. Is the critical path, or longest path in the presence of late-date constraints, calculated by the scheduling software valid? a. Are any activities in the schedule missing logic or constrained without justification? Are these issues resulting in an unreliable critical path? b. Is the critical path a continuous path from the status date to the major completion milestones?

	c. Does the critical path start with a constraint so that other activities are unimportant in driving the milestone date? If so, is there justification for that constraint? d. Does the critical path include LOE activities? Is the critical path driven by activities of unusually long duration? e. Is the critical path driven in any way by lags or leads? 2. Does management use the critical path to focus on activities that will have detrimental effects on key project milestones and deliveries if they slip? 3. Does the scheduling software identify activities that drive the dates of key deliveries and milestones? 4. If there are several important milestones, are the critical paths to them clearly identified, continuous, and free of constraints, LOE activities, leads, and lags?
Key Documentation	1. Important program deliverables or milestones for which critical paths should be established are identified. 2. Printouts of the logic diagram indicate the longest paths to the important milestones, as well as critical paths based on total float to all major milestones. 3. Near-critical paths are identified.
Likely Effects If Criteria Are Not Fully Met	1. Successfully identifying the critical path relies on capturing all activities (Best Practice 1), properly sequencing activities (Best Practice 2), horizontal traceability (Best Practice 5), the reasonableness of float (Best Practice 7), accurate status updates (Best Practice 9), and—if there are resource limitations—assigning resources (Best Practice 3). Unless the schedule is fully horizontally traceable, the effects of slipped activities on successor activities cannot be determined. If the schedule is missing dependencies or if activities are not linked correctly, float estimates will be miscalculated. Incorrect float estimates will result in an invalid critical path and will hinder management's ability to allocate resources from noncritical activities to those that must be completed on time. 2. Until the schedule can produce a true critical path, the program office will not be able to provide reliable timeline estimates or identify when problems or changes may occur and their effect on downstream work. 3. LOE activities should not drive the schedule. LOE and repetitive activities support effort, and their durations are determined by detail activities. For example, a project's length is not determined by biweekly meetings or program management. If the schedule has discrete durations and driving logic for LOE activities, it will potentially confuse the identification of, and deflect program attention away from,

the critical path. If LOE is critical, management has no indication of which activities can slip and which will respond positively to additional resources to reduce the risk of finishing late.

4. Without a valid critical path, management cannot focus on activities that will have detrimental effects on the key project milestones and deliveries if they slip.
5. Risk in activities on critical paths should be examined and mitigated because it has the potential to delay key program deliveries and milestones.
6. The review and analysis of near-critical paths is important because their activities are likely to overtake the existing critical path and drive the schedule.

Best Practice 7: Ensuring Reasonable Total Float

Key Questions

1. Are the total float values the scheduling software calculates reasonable and do they accurately reflect true schedule flexibility?
2. Are excessive values of total float being driven by activities that are missing logic?
3. Is total float calculated to the main deliveries and milestones as well as to the project's completion?
4. Is total float monitored? Does management have a plan to mitigate negative total float?
5. Does management rely on free float to level resources or reassign resources to assist critical activities?

Key Documentation

The project team can use a list of activities sorted by their total float values to determine whether the total float values correctly reflect flexibility in the project schedule.

Likely Effects If Criteria Are Not Fully Met

1. If the schedule is missing activities or dependencies or links activities incorrectly, float estimates will not be accurate. Incorrect float estimates may result in an invalid critical path and an inaccurate assessment of project completion dates. In addition, inaccurate values of total float falsely depict true project status, which could lead to decisions that may jeopardize the project. For example, if activities are not linked correctly to successors, total float will be greater than it should be.
2. Because the critical path is directly related to the logical sequencing of events and float calculations, if the schedule is missing dependencies

or if activities are incorrectly linked, float estimates will be miscalculated, resulting in an invalid critical path.

3. Without accurate values of total float, it cannot be used to identify activities that could be permitted to slip and thus release and reallocate resources to activities that require more resources to be completed on time.
4. Negative float indicates that not enough time has been scheduled for the activity and is usually caused by activities taking longer or starting later than planned, making target dates infeasible. The project may have to take some corrective action or the negative float may act as a lien against or threat to the project end date.
5. Too little float built into the schedule may indicate insufficient time to recover from delay without slipping the program's completion date.

Best Practice 8: Conducting a Schedule Risk Analysis

Key Questions

1. Was an SRA performed to determine the confidence level in achieving the program schedule and other key dates?
   a. Was the schedule checked to ensure that it meets best practices before the simulation was conducted?
   b. Are there data fields within the schedule for risk analysis such as low, most likely, and high durations?
   c. Were uncertainties in activity durations statistically correlated to one another?
   d. How much schedule contingency was selected and what is the probability of meeting the completion date?
   e. Did the SRA identify activities during the simulation that most often ended up on the critical path, so that near-critical path activities can be closely monitored?
2. Was a risk register used as an input to schedule development?
   a. Was the risk register used in identifying the risk factors potentially driving the schedule before the SRA was conducted?
   b. Once the SRA was conducted, were risks prioritized by probability and magnitude of impact?
3. Are the SRA data, assumptions, and methodology available and documented?

	4. Have the risk inputs been validated? Are the ranges reasonable and based on information gathered from knowledgeable sources? Is there evidence of bias in the risk data? 5. How is the use of schedule contingency controlled and authorized?
Key Documentation	1. A risk register with prioritized risks should be available. 2. SRA documentation should include assumptions, methodology, data, data normalization techniques, and findings. 3. If applicable, people should be listed who were interviewed or included in risk interviews, including their organization, position, or expertise. 4. The schedule risk analysis file is available.
Likely Effects If Criteria Are Not Fully Met	1. If a schedule risk analysis is not conducted, the following cannot be determined: a. the likelihood of the project's completion date, b. how much schedule risk contingency is needed to provide an acceptable level of certainty for completion by a specific date, c. risks most likely to delay the project, d. how much contingency reserve each risk requires, and e. the paths or activities that are most likely to delay the project. 2. Because activity durations are uncertain, the identity of the true critical path is also unknown unless a schedule risk analysis has been performed. An SRA can identify the paths that are most likely to become critical as the project progresses so that risk mitigation can lessen the effect of any delays. 3. Unless a statistical simulation is run, calculating the completion date from schedule logic and the most likely duration distributions will tend to underestimate the program's overall critical path duration. 4. If the schedule risk analysis is to be credible, the program must have a quality schedule that reflects reliable logic and clearly identifies the critical path. If the schedule does not follow best practices, confidence in the SRA results will be lacking. Without this analysis, the program office cannot sufficiently understand the level of confidence in meeting the program's completion date and identifying reserves for contingencies. 5. If the program does not have sufficient schedule reserve, then risk mitigation actions and schedule issues from unforeseen events may not be managed without a schedule delay. 6. If the task durations are not correlated to one another, the uncertainty on the critical path duration will be underestimated.

Best Practice 9: Updating the Schedule Using Logic and Progress

Key Questions

1. Is the schedule progress recorded periodically? Has the schedule been updated recently as planned? Is the status date recorded? Is at least one in-progress activity critical?
2. Do any activities have start or finish dates in the past without actual start or finish dates? Are there any activities with actual start or finish dates in the future?
3. Is responsibility for changing or statusing the schedule assigned to someone who has the proper training and experience in CPM scheduling?
4. Is there a list of logic changes that were made to the schedule during the update? Are there any comments in the schedule activities to document logic changes?
5. Were any activities started or completed out of sequence? If so, was the logic retained, or did the scheduler use progress override?
6. A schedule narrative accompanies each status update and includes
   a. the status of key milestone dates, including the program finish date;
   b. the status of key hand-offs or giver/receiver dates;
   c. explanations for any changes in key dates;
   d. changes in network logic, including lags, date constraints, and relationship logic and their effect on the schedule timeframe;
   e. a description of the critical paths, near-critical paths, and longest paths along with a comparison to the previous period's paths; and
   f. any significant scheduling software options that changed between update periods, such as the criticality threshold for total float, progress override versus retained logic, or whether or not resource assignments are progressed along with duration.
7. Is the schedule structure examined after each update to ensure that no logic is missing, constraints are necessary, and no activities impede the ability of the schedule to dynamically forecast dates?

Key Documentation

1. The schedule shows actual and planned dates, remaining duration for in-process activities, and the status date.
2. Copies of project management review (PMR) briefings to verify whether schedule status is discussed and consistent with the schedule.

Likely Effects If Criteria Are Not Fully Met

1. If the schedule is not continually monitored to determine when forecasted completion dates differ from planned dates, then it cannot be used to determine whether schedule variances will affect downstream work.
2. Maintaining the integrity of the schedule logic is not only necessary to reflect true status but is also required before conducting a schedule risk analysis. If the schedule has not been updated, then it is impossible to tell what activities have been completed, are in progress, are late, and are planned to start on time.
3. A schedule that has not been updated will not reflect what is actually occurring on the project and hence may have inaccurate completion dates and critical paths. When this is the case, management cannot use the schedule to monitor progress and make decisions regarding risk mitigation, resource allocations, and so on.
4. Unless a status date is provided, the schedule cannot be used to reliably convey effort spent and remaining.
5. A schedule with progress remaining out of sequence may have the wrong logic in place and, hence, inaccurate critical paths and completion dates.
6. If unfinished work remains in the past, the schedule no longer represents a realistic plan to complete the project, and team members will lose confidence in the model.
7. At least one in-progress activity is critical. If not, it is most likely that date constraints or external dependencies are separating subsequent from in-progress activities. Such breaks in the critical or longest path represent weak or incomplete logic, causing a lack of credibility in the identity of the path and the schedule dates.
8. Without a documented, consistently applied schedule change control process, project staff might continually revise the schedule to match performance, hindering the project manager's insight into the true performance of the project. Good documentation helps with analyzing changes in the program schedule and identifying the reasons for variances between estimates and actual results, thereby contributing to the collection of cost, schedule, and technical data that can be used to support future estimates.
9. Unless the schedule is kept updated, trend reports and analyses that highlight problems will not be useful in mitigating future delays.
10. Unless progress records are archived, historical data necessary for resource, work, and productivity assumptions for future analogous projects will not be available. If sufficient attention is paid to recording the way work is actually performed, the resulting archived data will help improve the accuracy and quality control of future similar projects.

Best Practice 10: Maintaining a Baseline Schedule

Key Questions	1. Is the baseline schedule the basis for measuring performance? 2. Does a baseline schedule document exist? Does the document a. describe the general approach to the project, define how to use the electronic schedule file, and describe the schedule's unique features? b. describe the schedule change management process? c. contain a dictionary of abbreviations, acronyms and custom fields? d. provide an overview of the assumptions and ground rules, including justification for calendars and any lags, constraints, or long activity durations? e. describe the use of resources within the schedule? f. describe the critical risks prioritized in a schedule risk analysis as well as schedule contingency? g. discuss the derivation of the critical paths and longest path and justify excessive total float? 3. Are changes to the baseline schedule reviewed and approved according to the schedule change control process? 4. Is trend analysis performed, such as monitoring start and finish dates, available float, and available schedule contingency? 5. Is there a large bow wave of work to the right of the status date that is unrealistic?
Key Documentation	1. The designated baseline schedule is available. 2. The schedule change control process is described. 3. The current schedule change control log is available. 4. The baseline schedule is documented.
Likely Effects If Criteria Are Not Fully Met	1. Without a formally established baseline schedule to measure performance against, management cannot identify or mitigate the effect of unfavorable performance. 2. Good documentation helps with analyzing changes in the program schedule and identifying the reasons for variances between estimates and actual results, thereby contributing to the collection of cost, schedule, and technical data that can be used to support future estimates. 3. Thorough documentation is essential for validating and defending a baseline schedule. A well-documented schedule can convincingly

argue for a schedule's validity and can help answer decision makers' and oversight groups' probing questions. A well-documented schedule is essential if an effective independent review is to ensure that it is valid and credible.

4. If changes are not controlled and fully documented, performance cannot be accurately measured against the original plan. Undocumented or unapproved changes will hamper performance measurement and may result in inaccurate variance reporting, inconsistent stakeholder versions of the plan, and unreliable schedule data.
5. Without a schedule change control process, traceability for all status updates will be unreliable, and there will be no guarantee that stakeholders are using the same version of the schedule.
6. Unless schedule variances are monitored, management will not be able to reliably determine whether forecasted completion dates differ from the planned dates.
7. Without trend analysis, management will lack valuable information about how a program is performing. Knowing what has caused problems in the past can help determine whether they will continue in the future.

Appendix III: Standard Quantitative Measurements for Assessing Schedule Health

An assessment of schedule best practices encompasses both qualitative and quantitative information. Qualitative information is provided by programmatic questions as such as those detailed in appendix I. These questions are related to the general policies in place and procedures undertaken to create and maintain the schedule. The quantitative assessment involves a detailed data analysis of the schedule data to determine the overall health of the network. While the specific questions addressed by the data analysis are also covered in appendix I, the quantitative assessment often involves specific filters and detailed data metric definitions. These filters and definitions are in table 4 for each best practice.

Table 4: Standard Data Measures for Schedule Best Practices

Best practice	Measure	Notes
1. Capturing all activities	Measures in Best Practice 1 provide basic information on the scope of the schedule, such as number and types of activities and the level of detail	
	Total number of activities, including total summary, hammock, milestone, and detail activities	Summary activities may or may not be present in the scheduling software
	Total number of remaining activities, including total summary, hammock, milestone, and detail activities	A remaining activity is any activity that is not complete. "Remaining" may be defined as (1) an activity with an actual start or no actual start and no actual finish or (2) any activity that is not 100 percent complete. Issues may arise with either definition. For instance, an activity may be noted as 100 percent complete and not have an actual finish date, or it may have an actual start and finish date but be less than 100 percent complete. Summary activities may or may not be present in the scheduling software
	If applicable, number of activities marked as both a milestone and summary activity	An activity cannot be both a summary and a milestone
	Number of activities with no descriptive name	May or may not be valid activities
	Ratio of detail activities to milestones	Provides a rough indicator of the level of planning detail in the schedule. While there is no specific threshold, 1 or 2 detailed activities per milestone is probably a very low level of detail, while 10 is probably highly detailed
	Number of activities not mapped to program or contractor work breakdown structure	
	Number of activities not mapped to a SOW or SOO paragraph or similar information	Depending on the nature of the effort, an activity may not be mapped to the statement of work
	Number of activities with duplicate names	Activity names should be unique and descriptive

Appendix III: Standard Quantitative Measurements for Assessing Schedule Health

Best practice	Measure	Notes
2. Sequencing all activities	Best Practice 2 includes more advanced measurements to assess the reliability of the network logic. Thresholds for metrics are not provided because, in theory, any missing or inappropriate logic may disrupt the entire network. The assessment of this best practice relies in part on the assessment of Best Practices 5, 6, and 7. If major deficiencies are identified in Best Practice 2, then a valid critical path, total float, and horizontal traceability are simply not possible. For minor deficiencies, an assessment of the schedule's critical path, total float, and response to tests of horizontal traceability are essential to understand the implications of constraints and incorrect or missing logic. Finally, all activities in a schedule, regardless of detail or planning period, are subject to this best practice	
	Number of remaining detail activities and milestones missing predecessor links	Does not include the start milestone; missing links to external activities (activities outside the scope of the current schedule file) may be excluded when a schedule is evaluated outside the IMS network
	Number of remaining detail activities and milestones missing successor links	Does not include the finish milestone; missing links to external activities (activities outside the scope of the current schedule file) may be excluded when a schedule is evaluated outside the IMS network
	Number of remaining detail activities and milestones missing both predecessor and successor links	
	Dangling activities: number of remaining detail activities and milestones with no predecessor on start date	Milestone activities may be excluded because their start and finish dates are the same; missing links to external activities (activities outside the scope of the current schedule file) may be excluded when a schedule is evaluated outside the IMS network
	Dangling activities: number of remaining detail activities and milestones with no successor or finish date	Milestone activities may be excluded because their start and finish dates are the same; missing links to external activities (activities outside the scope of the current schedule file) may be excluded when a schedule is evaluated outside the IMS network
	Number of remaining detail activities and milestones with start-to-finish links	Count either successor or predecessor links but do not count both. An S–F link is between two activities but represents only one link
	Number of remaining summary activities with logic links	May also be measured as "logic links to and from remaining summary activities," although this will be a different number
	Remaining detail activities and milestones with a great many predecessors	Assesses the schedule for path convergence. A relatively high number of predecessors may indicate a high-risk area. Note that not all predecessors are driving; only predecessors that have 0 or low float have the ability to delay the successor when they are delayed
	Remaining detail activities and milestones with soft date constraints	
	Remaining detail activities and milestones with hard date constraints	

Page 185 GAO-12-120G Schedule Assessment

Appendix III: Standard Quantitative Measurements for Assessing Schedule Health

Best practice	Measure	Notes
	Remaining detail activities and milestones with active SNET date constraints	If an activity's scheduled start date is the same as the SNET date, then the SNET constraint is more than likely preventing the activity from starting early. This is considered an active constraint. If an SNET constraint is earlier than the activity's start date, then the activity is not affected by the constraint date
	Remaining detail activities and milestones with active FNET date constraints	If an activity's scheduled finish date is the same as the FNET date, then the FNET constraint is more than likely preventing the activity from finishing early. This is considered an active constraint. If an FNET constraint is earlier than the activity's finish date, then the activity is not affected by the constraint date
	Remaining detail activities and milestones with lags	Count either successor or predecessor lags but not both. A lag is between two activities but represents only one lag. This is a different number from the number of lags
	Number of lags on remaining detail activities and milestones	Count either successor or predecessor lags but not both. A lag is between two activities but represents only one lag. This is a different number from the number of activities with lags
	Remaining detail activities and milestones with leads	Count either successor or predecessor leads but not both. A lead is between two activities but represents only one lead. This is a different number from the number of leads
	Number of leads on remaining detail activities and milestones	Count either successor or predecessor leads but not both. A lead is between two activities but represents only one lead. This is a different number from the number of activities with leads
	Remaining detail activities and milestones with an F–S predecessor lead greater than remaining duration	
3. Assigning resources to all activities	Best Practice 3 is more programmatic than quantitative, although metrics and trends may be investigated for fully resource loaded schedules. If possible, resource assignments over time may be evaluated to identify potential unrealistic bow waves. In general, the measures assess the number of activities within the detail planning period that are assigned resources and the reasonableness of work hours. Overallocated resources and unrealistic resource units should be a cause for concern. Care should be taken to assess only the appropriate detailed activities	
	Total number of resources	
	Overallocated resources	
	Maximum units available per resource	Individuals should be available between 0 and 100 percent of full time, and resource groups should have a realistic number of individuals available to perform the work.
	Remaining detail activities with assignments	Exclude nonapplicable activities such as planning packages, LOE activities, and reference activities
	Remaining detail activities without assignments	
4. Establishing the durations of all activities	Measures for Best Practice 4 are generally straightforward, providing an overall assessment of the detail available to management, as well as the appropriateness of the schedule calendars. Care should be taken to assess only the appropriate detailed activities	
	Remaining detail activities with dissimilar time units	All durations should be in the same unit, preferably days

Page 186 **GAO-12-120G Schedule Assessment**

Appendix III: Standard Quantitative Measurements for Assessing Schedule Health

Best practice	Measure	Notes
	Remaining detail activities with durations less than 44 days	Exclude nonapplicable activities such as planning packages and LOE and reference activities. The analyst should take into account baseline durations if available. That is, if the baseline duration is 35 days but the actual plus remaining duration is 60, the original baseline meets the intent of the best practice
	Remaining detail activities with durations greater than 44 days	
	Average duration of remaining detail activities	
	Median duration of remaining detail activities	
	Holidays and other exceptions by task calendar	
	Remaining detail activities or milestones starting or finishing on a weekend or holiday	May be legitimate but stem from incorrect calendar assignments or specifications. Milestones on weekends or holidays are particularly suspicious
5. Verifying that the schedule can be traced horizontally and vertically	Best Practice 5 has no standard measurements. Vertical traceability is assessed by determining whether lower-level tasks fall within the same timeframe as higher-level tasks and whether detailed schedule dates fall within the same timeframe as summary schedule dates. An essential check of vertical traceability is determining whether forecasted milestone dates in detailed schedules match those quoted in management briefings. Horizontal traceability depends on Best Practice 2, although not entirely as noted in that best practice. It is assessed by increasing activities' durations by improbable amounts (500 or 1,000 days) and observing how the schedule reacts. In the absence of constraints and assuming logic has been properly identified, key milestones should move and the critical path should change	
	Assessment of how critical and noncritical planned dates dynamically react to dramatic increases in predecessor activity durations	Horizontal traceability implies that the network responds dynamically to delayed activities. Severely delayed activities should become critical and previously critical paths should become noncritical. Delays of this magnitude should cause the finish date to slip relative to the activity delay
6. Confirming that the critical path is valid	Best Practice 6 has no standard measurements for assessing the critical path. Beginning at the program finish milestone, the sequence of driving activities is traced back to the status date. This sequence of activities should be straightforward, continuous, and the same as the critical path—defined by zero total float—in the absence of date constraints. Date constraints will convolute the critical path and cause activities to be critical that may not necessarily be driving the finish milestone. Critical paths to interim key milestones may also be assessed as applicable	
	Assessment of the driving paths to key milestones and comparison of those paths to activities marked as critical in the schedule	Ideally the driving path and critical path are the same to the key milestone. The path should be continuous from the status date to the key milestone and should be free of lags
7. Ensuring reasonable total float	Best Practice 7 includes basic measurements of total float to assess overall program flexibility as reported by the schedule. It is closely related to assessments of Best Practices 2, 5, and 6, because a properly sequenced network will produce reasonable estimates of float and a valid critical path. It has no thresholds or tripwire metrics; as discussed in Best Practice 7; reasonableness is assessed in combination with program length and activity type. In addition, because one logic error can cause an entire sequence of activities to report unreasonable amounts of float, the breadth of deficiencies reported in Best Practice 2 should be taken into account here. Negative float should always be questioned	
	Remaining detail activities and milestones with dissimilar total float time units	All float should be in the same units, preferably days
	Remaining detail activities and milestones with relatively high total float	High float is relative to the scope, length, and complexity of the schedule. Float should be reasonable and realistically reflect the flexibility of the schedule

Page 187 **GAO-12-120G Schedule Assessment**

Appendix III: Standard Quantitative Measurements for Assessing Schedule Health

Best practice	Measure	Notes
	Remaining detail activities with negative total float	Negative total float indicates the activity's constraint date is earlier than its calculated late finish. Negative float occurs when activities are performed out of sequence
	Average total float value of remaining detail activities and milestones	
	Median total float value of remaining detail activities and milestones	
8. Conducting a schedule risk analysis	Many quantitative measurements are related to Best Practice 8, and a proper schedule risk analysis typically deserves a much more complex quantitative assessment than that given here. GAO's assessment of Best Practice 8 is more programmatic, and these questions are provided in appendix I. The metrics for Best Practice 8 are limited to determining the existence of risk data within the schedule risk file	
	Fields within the schedule used for SRA	Fields that store low, most likely, and high durations
	Correlation measures within the schedule	
	Contingency activities	
9. Updating the schedule using actual progress and logic	Best Practice 9 is assessed by determining the validity of the dates reported in the schedule. The assessment of this best practice is dependent entirely on the status date reported in the schedule	
	Number of in-progress activities	Any activity that is not complete. "Remaining" may be defined as either (1) an activity with an actual start or no actual start and no actual finish or (2) any activity that is not 100 percent complete. Issues may arise with either definition. For instance, an activity may be noted as 100 percent complete and not have an actual finish date, or it may have an actual start and finish date but be less than 100 percent complete
	Number of remaining detail activities and milestones that have a start date in the past but no actual start date	Planned start dates should not occur in the past. "Past" is defined by the status date
	Number of remaining detail activities and milestones that have a finish date in the past but no actual finish date	Planned finish dates should not occur in the past. "Past" is defined by the status date
	Number of remaining detail activities and milestones that have an actual start date in the future	Actual start dates should not occur in the future. "Future" is defined by the status date
	Number of remaining detail activities and milestones that have an actual finish date in the future	Actual finish dates should not occur in the future. "Future" is defined by the status date
	Number of detail activities performed out of sequence	
10. Maintaining a baseline schedule	Many data measures can be used to assess Best Practice 10, some are provided here. All baseline measures ultimately depend on the existence of a controlled baseline and a properly statused current schedule. Baseline measures are typically calculated by reporting period: for example, number of activities forecasted to start early over the next 60 days or activities that have actually finished late over the last 6 months. They may also be useful when applied to specific products within the WBS, resource groups, or criticality: for example, the number of late activities during product integration, the average start variance of activities executed in one production plant, or the baseline execution index of activities with less than 10 days of total float	

About the Author

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Hilal Al Rashdi is currently working with Oman Power and Water Procurement Company as a project engineer. After completing six months of training rotation in the company departments, he was assigned to Project Implementation Department to monitor the projects under implementation stage, specifically construction and commissioning stages. He has one year experience in Power and Water Project focusing in HSE requirement, contract compliance, interfaces and project quality and delivery to operation team. Currently, he is monitoring two water desalination projects (Qurayyat Independent Water Plant & Barka IV Independent Water Plant) and one power generation project (Ibri Independent Power Plant). Hilal holds B.Sc. in Chemical Engineering from University of Kentucky, United States of America. He can be contacted at hilal.alrashdi@omanpwp.com