How to write a Model Scheduling Specification Incorporating the GAO's "Best Practices in Scheduling" Appendices[1]

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ABSTRACT

To develop a scheduling specification with an appropriate type of specifying was researched in this paper. Considering world-class CSI manual of practices and Texas DoT for specification template and Master Format 2004 from CSI & CSC for coding structure with incorporating "GAO's Best Practices in Scheduling" in scheduling specification. By conducting proper analysis with Engineering Economic Analysis Procedure to develop the scheduling specification with seven steps. In the analysis, powerful decision-making tools like SWOT analysis to refine from the four types of specifying to the appropriate two, then through force field analysis, select the most preferred type of specifying to develop the scheduling specification. Performance specification is the selected type of specifying from the alternatives to develop the Model Scheduling Specification. Hence a robust scheduling specification has developed adopting best practices from the standards and GAO's Best Practices as appendices to this paper.

Keywords: Performance Specification, Contractual, writing style, contractor, Scheduling

INTRODUCTION

Specifications are one of the essential components that make up the contract agreement between the owner and the contractor.[2] "Specifications define the requirements for products, materials, and workmanship upon which the contract is based and the requirements for administration and performance of the project."[3] "They are written to achieve a work result." A specification is clear, concise, accurate, and easily understood. In most countries, the specification is part of the contractual documents. Then only the contractor will follow the specifications without hesitant. It's essential to select the type of specification and adopt the writing style. The techniques used in the preparation of specifications involve the development of sections from the product reference material and editing section from other references. In developing specifications, the preliminary step is to gather information regarding the project-

[1] How to cite this paper: Kurian, T. (2019). How to write a Model Scheduling Specification Incorporating the GAO's "Best Practices in Scheduling" Appendices. *PM World Journal*, Vol. VIII, Issue XI, December.
[2] Specification Writing - Fundamentals of Structure .... https://www.bicsi.org/docs/default-source/conference-presentations/2017-winter/specification-writing.pdf?sfvrsn=9d504f43_2
[3] Specification Writing - Fundamentals of Structure .... https://www.bicsi.org/docs/default-source/conference-presentations/2017-winter/specification-writing.pdf?sfvrsn=9d504f43_2

specific requirements and product selection decisions, require systematics and progressive compiling information in the early design phases.

There are several decisions to be taken on the outset of specification preparation. Before writing the original sections for a project, the type and organization of the specification must be decided upon. Information collected should be developed in the three-part section format, which provides consistency in the presentation of information and allows us to a wide variety of projects. A decision must be taken on the appropriate method of specifying. Sometimes more than one method may be necessary for the same specification or in the same section.

Specification Language

Specification language, requires correct usage of vocabulary, grammar along with the correct sentence and paragraph construction. In the specification language, four principles of effective communication should follow, Clear, Concise, Correct, and Complete.

5.8 SPECIFICATION LANGUAGE

As legally enforceable contract documents, construction specifications should be prepared with concern and respect for their legal status.

The four Cs for effective communication are:

- CLEAR. Use proper grammar and simple sentence construction to avoid ambiguity.
- CONCISE. Eliminate unnecessary words, but not at the expense of clarity, correctness, or completeness.
- CORRECT. Present information accurately and precisely. Carefully select words that convey exact meanings.
- COMPLETE. Do not leave out important information.

Specification Language [4]

These principles have adopted from CSI best Tested and proven practices. For effective communication, these four Cs are important to be followed. Usage of proper grammar and simple sentence construction will adopt for the model specification. Remove unnecessary words, and it should not lead to unclear, incorrect, or incomplete. Convey correct meaning by selecting proper words. Important information should be included in the specification.

[4] The Construction Specification Institute. (2004). Division 01-General Requirements. In The Project Resource Manual (PRM) : CSI Manual of Practice, 5th Edition: CSI Manual of Practice, 5th Edition (2004 ed., p. 5.69). New York, NY: McGraw Hill Professional.

Generally, the imperative mood should be maintained throughout the specification. In the CSI standard, two-sentence moods can be selected, Imperative, and Indicative mood. Since Imperative mood is the recommended method for instructions covering to perform particular tasks. In this, the verb comes the first word in the sentence, which clearly defines the action. And the imperative sentences are easily understandable and concise. For, e.g., "Avoid negative lags in the schedule. The use of terminology and language contributes consistently to better communication and which will minimize confusion and ambiguity. Avoid Contradicting requirements or duplicating contained else anywhere in the specification. To eliminate overlapping requirements and omissions, the early distribution of a draft of specifications will help. One of the basic requirements is that a section title list to be developed along with the scope of work. It is used for the coordination among sections and helps to prevent overlaps and omissions.

5.8.4 Sentence Structure

Two basic grammatical sentence moods can be used to clearly convey specification requirements:

- Imperative mood
- Indicative mood.

5.8.4.1 Imperative Mood: The imperative mood is the recommended method for instructions covering the installation of products and equipment. The verb that clearly defines the action becomes the first word in the sentence. The imperative sentence is concise and readily understandable.

- Spread adhesive with notched trowel.
- Install equipment plumb and level.
- Apply two coats of paint to each exposed surface.

5.8.4.2 Indicative Mood: The indicative mood, passive voice requires the use of *shall* in nearly every statement. This sentence structure can cause unnecessary wordiness and monotony.

- Adhesive shall be spread with notched trowel.
- Equipment shall be installed plumb and level.
- Two coats of paint shall be applied to each exposed surface.

Sentence Structure [5]

Some other factors may affect the level of requirements, extent, cost, and schedule of a project, such as the economic impact of the requirements stated in specifications, construction trade structure, availability of products, and quality assurance & control in the contract.

The writing style is the cornerstone of readability, ensuring text is relevant and capable of being clearly understood by its intended readership. The style includes a good approach to grammar, simple sentence structure, and correct punctuation. The style concerning specification writing means Clarity, Accuracy, Repetition, Brevity, and Logic.

[5] The Construction Specification Institute. (2004). Division 01-General Requirements. In The Project Resource Manual (PRM) : CSI Manual of Practice, 5th Edition: CSI Manual of Practice, 5th Edition (2004 ed., p. 5.70). New York, NY: McGraw Hill Professional

"**Clarity:** Use simple sentence for sentence construction. And as per the CSI manual practices sentence structure in imperative statements. Clarity means using plain English as well as restricting vocabulary to words in common usage. Using punctuation in sentences carefully, if not, it may change the meaning of the sentence and creates ambiguity. In the contract agreement, only two parties are there owner and contractor, and all instructions are addressed to the contractor to perform or follow. Generally, the word " The contractor shall" are omitted in most cases but may be added for more clarity when both parties are mentioned in the same article or paragraph.

incorporation into the project. Materials and products are included with their quality requirements.

PART 3 EXECUTION. Describes installation or application, including preparatory actions and postinstallation cleaning and protection. Site-built assemblies and site-manufactured products and system are included.

Sections are not intended to stand alone. They function with other portions of the procurement and contract documents and must relate to them. For example, PART 1 GENERAL describes administrative and procedural requirements specific to the subject being covered. The requirements described in PART 1 should not duplicate statements that are contained in sections of Division 01. Each article and paragraph should supplement and be coordinated with the applicable sections of Division 01 to avoid repetition or conflicting requirements.

Repetition[6]

E.g., Use 'Avoid lags with Finish to start a relationship .....' not 'The contractor shall avoid lags with Finish to start a relationship.'

"**Accuracy:** Using simple terms like use, supply, submit, which ensures consistency and accuracy and of the repeated clauses. " Avoid generalizations, or unclear words or phrasing. Avoid acronyms and abbreviations, unless very well known and incapable of simple error. Blanket clauses implying a responsibility for the general or the unknown must be avoided.

Avoid listing overly specific, or indefinable requirements such as 'best trade practice,' 'first-class work,' or 'acceptable standard.' Only require 'approval' or 'inspection by....' where this fulfills some specific purpose".[7]

[6] The Construction Specification Institute. (2004). Division 01-General Requirements. In *The Project Resource Manual (PRM) : CSI Manual of Practice, 5th Edition: CSI Manual of Practice, 5th Edition* (2004 ed., p. 5.37). New York, NY: McGraw Hill Professional.

[7] SPECIFICATION WRITING GUIDANCE - transport.nt.gov.au. https://transport.nt.gov.au/__data/assets/pdf_file/0020/234155/specification-writing-guidance-booklet.pdf

Repetition: Repeating the same contents in the documents is awkward, and it is inadvisable to follow Documents that are meant to be complimentary. The principles to follow are. If the information available in the conditions of the contract, then it is not required to mention in the specification part. Sometimes information available on the drawings and the same need not to be mentioned in the specification.

Brevity: As per the CSI standard, it is clear that provide enough information to do it properly and avoid oversimplification may lead to redundant sentences.

Logic: As per the CSI Manual practice, the Subject /Verb agreement is important. It recommended that singular verbs should be used with singular subject and plural verbs with plural subjects. Instructions should be given as a direct statement. Hence it is clear, concise, correct, and complete. In the specification, the headings and subheadings have a logical numbering system, which shows in the Master format snapshot below gives a clear understanding. Cross-referencing should be kept minimum, because of possible future changes or project-based modifications. Have matters of contract and administration separate from the technical sections of the Specification, except for specific instructions on quality or for instructing/informing others (such as a sub-contractor).

5.8.10 Grammar

5.8.10.1 Subject/Verb Agreement: The subject and the verb must always agree in number. Singular verbs should be used with singular subjects and plural verbs with plural subjects. An error in number is easy to make when a sentence is long and complicated. The singular subject of a sentence can be confused with a plural modifier.

- *Incorrect:* One of the elongated central fasteners are to be placed around the eye of the panel and bolted.
- *Correct:* One of the elongated central fasteners shall be placed around the eye of the panel and bolted.
- *Preferred:* Bolt one elongated central fastener to panel eye.

The incorrect example uses the singular subject *one* with the plural verb *are*. The grammatically correct example has number agreement between subject

Grammar [8]

[8] The Construction Specification Institute. (2004). Division 01-General Requirements. In *The Project Resource Manual (PRM) : CSI Manual of Practice, 5th Edition: CSI Manual of Practice, 5th Edition* (2004 ed., p. 5.37). New York, NY: McGraw Hill Professional.

	A	B
1	***MasterFormat* 2004 Edition - Numbers and Titles**	
2	The Construction Specifications Institute	Date: October 2005
3		For more information on *MasterFormat*, visit www.csinet.org/masterformat
4		Copyright 2004, 2005 CSI & CSC, all rights reserved
5	**2004 Edition *MasterFormat* - Complete Listing**	
6	**04 SECTION**	**04 TITLE**
313	**01 32 00**	**Construction Progress Documentation**
314	01 32 13	Scheduling of Work
315	01 32 16	Construction Progress Schedule
316	01 32 16.13	Network Analysis Schedules
317	01 32 19	Submittals Schedule
318	01 32 23	Survey and Layout Data
319	01 32 26	Construction Progress Reporting
320	01 32 29	Periodic Work Observation
321	01 32 33	Photographic Documentation
322	01 32 43	Purchase Order Tracking

Heading and logical numbering system is shown in Master Format [9]

This paper intends to research the different types of specifications and other relevant attributes such as writing style, format, structure, etc. that to be considered for the specification writing.

The objective of the paper to select an appropriate type of specification to "write the specifications for schedule preparation." Thereby owners can adopt the Model Specification for Scheduling in their contract to follow by the contractors. It gives a proper guideline to the contractors about the scheduling best practices, procedures, and document transmitting options.

"Construction scheduling specifications can be relatively long and elaborated. They often end up in the general provisions and can be the most extended general provision in your specification.

A right scheduling specification will address:

1. Definitions
2. Administrative Requirements
3. Technical Requirements[10]"

Construction Specifications Institute. (2004). *Master Format* (2004 ed.).

[10] Scott Lowe ,P.E. (n.d.). The Components Of A Good Construction Scheduling Specification. Retrieved from https://www.traunerconsulting.com/the-cohttps://www.traunerconsulting.com/the-components-of-a-good-construction-scheduling-specification/mponents-of-a-good-construction-scheduling-specification/

ANALYSIS METHODOLOGY

TABLE 1-1 The General Relationship between the Engineering Economic Analysis Procedure and the Engineering Design Process

Engineering Economic Analysis Procedure	Engineering Design Process (see Figure P1-15 on p. 18)
Step	*Activity*
1. Problem recognition, definition, and evaluation.	1. Problem/need definition.
	2. Problem/need formulation and evaluation.
2. Development of the feasible alternatives.	3. Synthesis of possible solutions (alternatives).
3. Development of the outcomes and cash flows for each alternative.	
4. Selection of a criterion (or criteria).	4. Analysis, optimization, and evaluation.
5. Analysis and comparison of the alternatives.	
6. Selection of the preferred alternative.	5. Specification of preferred alternative.
7. Performance monitoring and post-evaluation of results.	6. Communication.

Analysis Methodology[11]

Analysis methodology has adopted here is the Engineering Economic Analysis Procedure, which related to the Engineering Design Process. The seven steps in the analysis procedure should produce a robust analysis, and appropriate specifying types from the standards can be adapted to produce the Model specifications.

Step 1- PROBLEM STATEMENT

The purpose of this paper is to select an appropriate specification type to develop a scheduling specification which can be incorporated in the contract

Step 2- FEASIBLE ALTERNATIVES

For developing a specification, there are four types of specifying as Method specifications, performance specifications, Reference standard specifications, and Proprietary specifications.

Method Specifications

Method specifications also are known as Material and method specifications or Descriptive specifications or Prescriptive specifications. In this specification, its to identify the material and

[11] Sullivan, W. G., Wicks, E. M., & Koelling, C. P. (2014). Introduction to Engineering Economy. In *Engineering Economy* (16th ed., p. 7). Harlow, England: Pearson.

the work method to complete the work by the contractor as specified in the contract. "Method specifications typically operate on the principle that if the specified materials and methods worked in the past, then the end product is likely to perform well in service so long as the contractor strictly adheres to the prescribed requirements."[12]

Performance specifications

"Performance specifications describe the required work in terms of operational characteristics or ultimate use. The performance characteristics are designed to predict or monitor performance over time. Unlike method specifications, performance specifications tend not to include instructions that dictate or suggest methods, material definitions, material processing, time and temperature controls, constituent properties, construction equipment descriptions, and similar prescriptive elements."[13]

Reference standards

"Reference standards refer to specifications prepared by professional societies, recognized trade associations, standards writing organizations or agencies that provide national standards of performance or measurement. These specifications have been proven over time to provide the desired quality. Reference standards may include prescriptive requirements, but more typically include end-result requirements, criteria, and tests to meet a desired standard of performance. They can be included in a performance or method specification."[14]And a scheduling manual is adopted which has best tested and proven practices is in GAO Schedule Assessment Guide – Best Practices for Project Schedules as reference standards.

Proprietary specifications

"Proprietary specifications identify the desired products or processes by brand name, manufacturer's name, model number, or other unique characteristics. Even if a manufacturer is not explicitly stated, a specification can still be considered proprietary if only one manufacturer can meet the specified requirements. Designers often specify proprietary products to produce what they perceive to be a "tight" specification that allows for close control of product selection and a higher level of design based on more precise information obtained from manufacturer's data. However, this practice experiences the potential disadvantages of narrowing competition or unnecessarily eliminating or requiring products with which the contractor has perhaps had poor or little experience (e.g., slow delivery) situations that may lead to charges of favoritism or higher bid prices."[15]

[12] Construction - Federal Highway Administration. https://www.fhwa.dot.gov/construction/specrevattach1.cfm
[13] Construction - Federal Highway Administration. https://www.fhwa.dot.gov/construction/specrevattach1.cfm
[14] Construction - Federal Highway Administration. https://www.fhwa.dot.gov/construction/specrevattach1.cfm
[15] Construction - Federal Highway Administration. https://www.fhwa.dot.gov/construction/specrevattach1.cfm

Step 3- DEVELOPMENT OF THE OUTCOMES ON ALTERNATIVES

In the section, a detailed analysis to be done to determine which alternative is most suitable for developing a Specification for Scheduling Practices. The analysis of the feasible alternatives shall be done by conducting a SWOT analysis for each alternative.

SWOT Analysis of Method Specification

Method Specifications		
	STRENGTH	WEAKNESS
INTERNAL	*Specifies properties of materials and methods for installation without propietary names *Characterisitcs and physical properties and workmanship	*Requires good technical knowledge and experience * Research on available products
EXTERNAL	* Work methodology shall be specified * Owner can exert greater control over the work *Historically proven methods used for works hence risk can be eliminated on new methods	*Little opportunity to the contractor to deviate from the specifications *Leads to dispute due to inherent variablity in material fail to recognize
	OPPORTUNITIES	THREATS

SWOT Analysis of Method Specifications[16]

SWOT Analysis of Performance Specification

[16] By Author

Performance Specifications		
	STRENGTH	**WEAKNESS**
INTERNAL	*Required work in terms of operational characteristics *Contractor is free to choose materials and methods complying with the performance criteria. *Description of the required end result	* No methodology or material definitions shall be mentioned
EXTERNAL	* Increase the potential for contractor innovation. * End product performance is measurable. *Testing is rapid, available, and economical.	* Incomplete performance specification results in quality control over material and methods. * The contractor assumes more performance risk.
	OPPORTUNITIES	**THREATS**

SWOT Analysis of Performance Specifications[17]

SWOT Analysis of Reference Standard Specification

Reference Standard Specifications		
	STRENGTH	**WEAKNESS**
INTERNAL	* Standards can be incorporated in method or performance specification * Embbeded option of standards	* Standards shall be revised peroidically and may miss out to incorporate *May leads to misinterpretation by contractors * Using multiple standards leads to conflicts
EXTERNAL	* Wide range of standards available	* Duplicate or contradict other requirements * Often define minimum requirements
	OPPORTUNITIES	**THREATS**

SWOT Analysis of Reference Standard Specifications[18]

[17] By Author
[18] By Author

SWOT Analysis of Proprietary Specification

Proprietary Specifications		
	STRENGTH	**WEAKNESS**
INTERNAL	* Product selection can be closely controlled. * Reduced cost and time benefits may be obtained from use of shorter specifications	* Competition for products is reduced or eliminated. *Bidding may be simplified by narrowing competition and removing product pricing as a major variable. *Only one product is named in closed proprietary specifications
EXTERNAL	* Prices are requested for specified alternative products. *Substitutions and cost adjustments may be proposed by the bidders.	* Certain products and manufacturers may be favored over others. * An error might occur when specifying model or product designations
	OPPORTUNITIES	**THREATS**

SWOT Analysis of Proprietary Specifications[19]

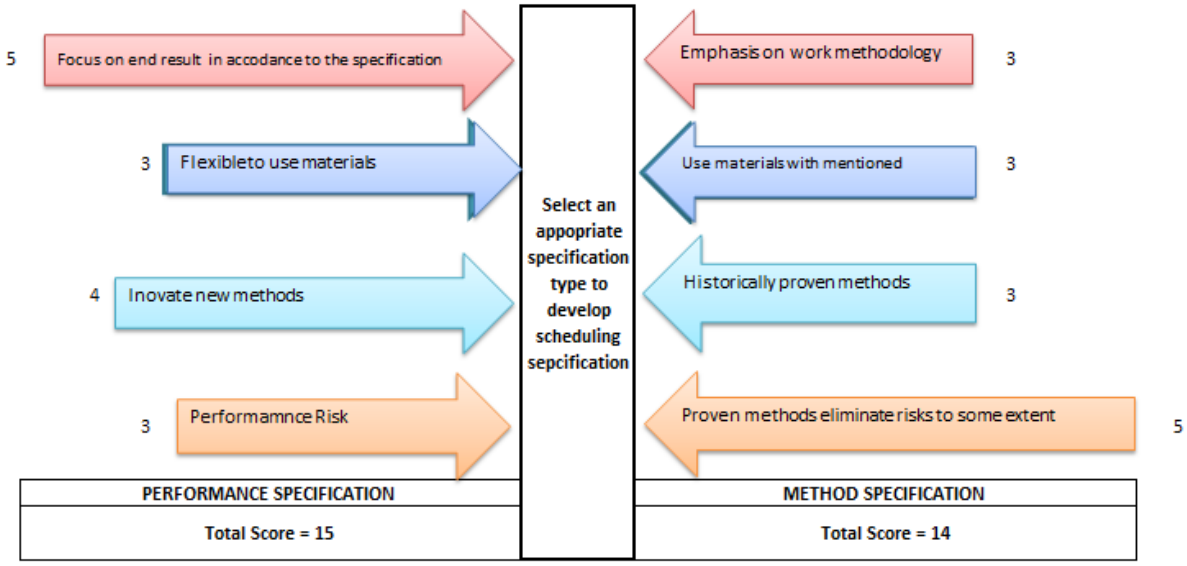
The SWOT analysis was carried out for the four types of specifications; from this, the two most appropriate types shall be taken for further analysis by force field analysis to select the best one for the purpose.

For Force field analysis, two prominent types are considered based on the SWOT analysis are Method Specifications and Performance Specifications.

Step 4- SELECTION CRITERIA

The selection of specification type can be selected as the highest score obtained in the force field analysis among the selected alternatives on SWOT analysis. Then the selection will be more accurate to the appropriate type to be used.

[19] By Author



Force Field analysis for selected specification type [20]

Step 5- SELECTION OF THE PREFERRED ALTERNATIVE

From the research, the Performance specification method was selected to develop the scheduling specification among the alternatives. From SWOT analysis, the most appropriate two types have selected and through Force field analysis, reached the preferred one for the scheduling specification. The specification template has adopted from the CSI Manual of Practices which is the Best tested and proven practices, and all attributes has been adopted from the CSI Manual of Practices and Texas DoT which conforms to the GAO's Schedule Assessment Guide – Best Practices of Project Schedules is the best tested and proven practices in scheduling as reference standards to the scheduling specification in Appendix I

Step 6-MODEL PERFORMANCE SPECIFICATION TEMPLATE FOR SCHEDULING [21]

The format used for developing specifications is CSI's Manual of Practice, and the coding structure is Master Format from CSI. It is important to prepare specifications for schedule development since this can be an exclusive reference /guideline for developing and maintaining project CPM schedules.

[20] By Author
[21] Construction Specifications Institute. (2004). *Master Format* (2004 ed.)., & Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

PART 1 GENERAL

SUMMARY
- Section Includes
- Products Supplied but not Installed Under This Section
- Products Installed but not Supplied Under This Section
- Related Sections
- Allowances
- Unit Prices
- Alternates

REFERENCES

DEFINITIONS

SYSTEM DESCRIPTION

SUBMITTALS
- Prior to Bid
- With Bid
- Prior to Fabrication
- Prior to Installation
- Prior to Final Acceptance

QUALITY ASSURANCE
- Qualifications
- Manufacturer Qualifications
- Bidder Qualifications
- Designer Qualifications
- Installer Qualifications
- Testing Agency Qualifications

DELIVERY, STORAGE, AND HANDLING

PROJECT/SITE CONDITIONS
- Environmental Requirements
- Existing Conditions
- Field Measurements

SEQUENCING

SCHEDULING

WARRANTY
- Special Warranty
- Guaranty/Bond

MAINTENANCE
- Extra Materials
- Maintenance Service

PART 2 PRODUCTS

PERFORMANCE
- Attributes
- Requirements
- Criteria
- Tests

COMPONENTS
- Attributes
- Requirements
- Criteria
- Tests

SOURCE QUALITY CONTROL

PART 3 EXECUTION

EXAMINATION

PREPARATION
- Protection
- Surface Preparation

ERECTION/INSTALLATION/APPLICATION

FIELD QUALITY CONTROL

ADJUSTING

CLEANING

PROTECTION

SCHEDULES

Performance Specification Format[22]

[22] The Construction Specification Institute. (2004). Performance Specifying. In The Project Resource Manual (PRM) : CSI Manual of Practice, 5th Edition: CSI Manual of Practice, 5th Edition (2004 ed., p. 5.156). New York, NY: McGraw Hill Professional.

From the CSI Manual of Practices, Performance Specification format is depicted here to follow to develop the Model Scheduling Specification. The format shows many attributes related to Performance Specification in the some are not applicable for the Model Scheduling Specification in Appendix I. The coding structure from Master format 2004 used for the specification is " 01 32 00 " and Project schedule submission code is "01 32 16" for the contractor for the initial submission and Monthly updated schedule submission code is "01 32 16 – (Calendar Month) for the filling purpose.

	A	B
1	***MasterFormat* 2004 Edition - Numbers and Titles**	
2	The Construction Specifications Institute	Date: October 2005
3		For more information on *MasterFormat*, visit www.csinet.org/masterformat
4		Copyright 2004, 2005 CSI & CSC, all rights reserved
5	**2004 Edition *MasterFormat* - Complete Listing**	
6	**04 SECTION**	**04 TITLE**
313	**01 32 00**	**Construction Progress Documentation**
314	01 32 13	Scheduling of Work
315	01 32 16	Construction Progress Schedule
316	01 32 16.13	Network Analysis Schedules
317	01 32 19	Submittals Schedule
318	01 32 23	Survey and Layout Data
319	01 32 26	Construction Progress Reporting
320	01 32 29	Periodic Work Observation
321	01 32 33	Photographic Documentation
322	01 32 43	Purchase Order Tracking

Coding Structure from Master Format 2004[23]

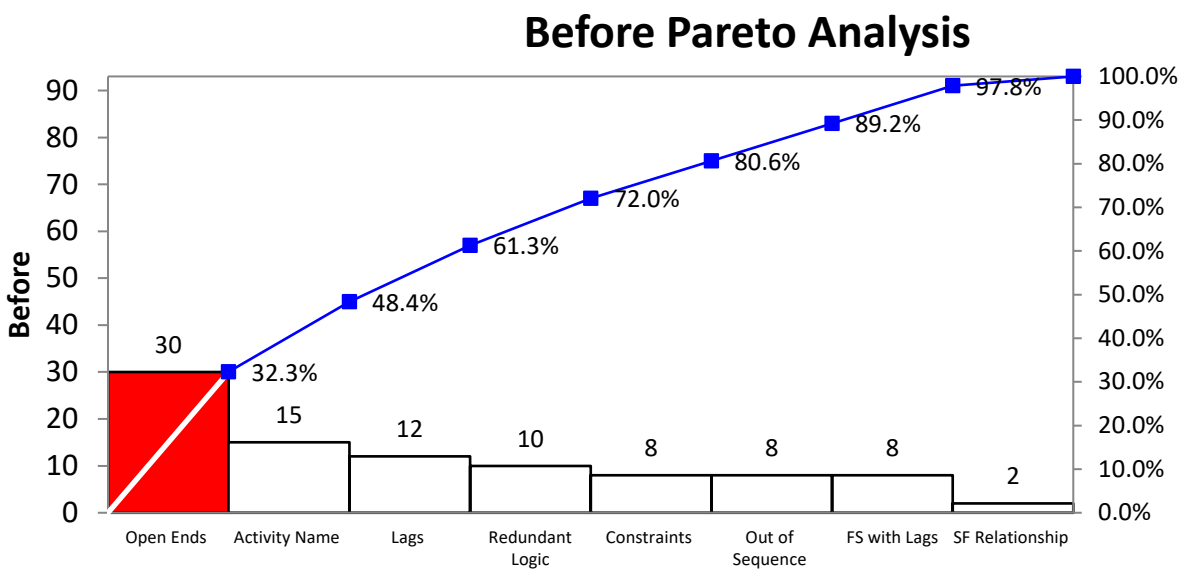
Step 7- POST PERFORMANCE EVALUATION USING PARETO ANALYSIS

Once after the implementation of these specifications in project schedules, then a drastic change in the quality of schedule can be observed and tracked by using "Before" and "After" Pareto Analysis. The Pareto law tells us 80% of the problems come from 20% of the potential causes.

Here is an example of a "before" and "after" Pareto Chart to illustrate the follow on the process will be conducted.

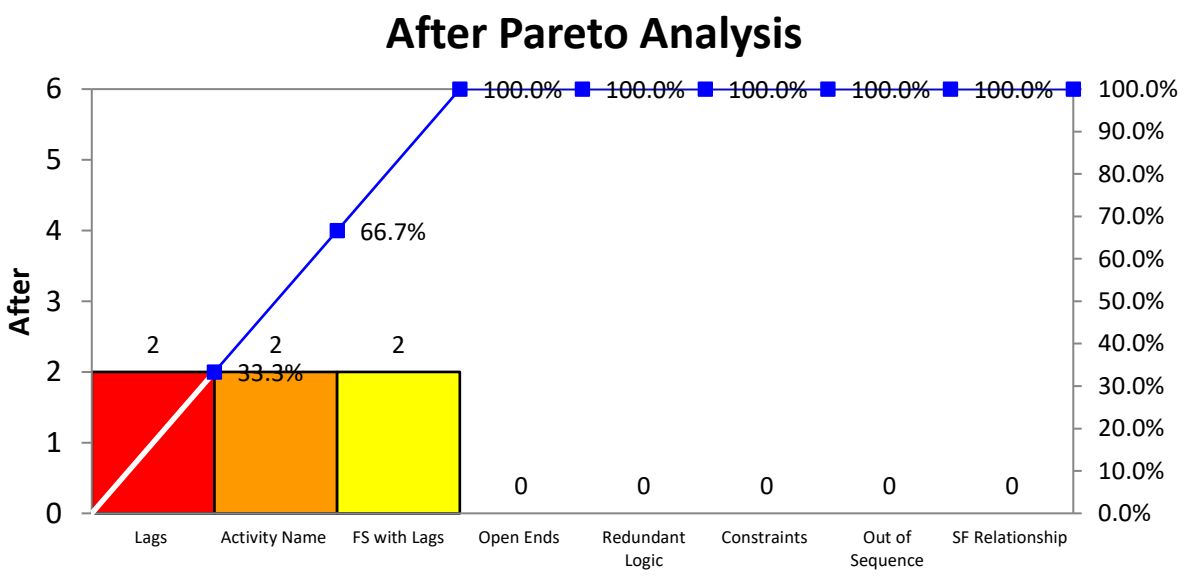
A schedule had selected from a contractor's initial submission and conducted" Before Pareto analysis" against the best practices and notified the contractor to comply with it. And the result obtained from" Before Pareto Analysis "depicted below.

[23] Construction Specifications Institute. (2004). *Master Format* (2004 ed.).



Before Pareto Analysis[24]

According to the comments, the contractor has fixed the errors to comply with the best scheduling practices. On the next submission of the contractor's schedule, an "After Pareto Analysis" had conducted to demonstrate the difference when they complied with the scheduling specifications mentioned in this paper. The "After Pareto Analysis" results obtained are depicted below.



After Pareto analysis[25]

[24] By author

From the Pareto analysis, it is clear that the implementation of specifications will change a good improvement in the schedule, which shows Before and after Pareto analysis.

CONCLUSION

The purpose of this paper was to select an appropriate type of specifying for a "Model Scheduling Specification." Through seven steps of The Engineering Economic Analysis procedure considering the best tested and proven template from CSI 's Manual of Practice and Texas DoT in developing of specification with incorporating GAO's Best Practices in Scheduling, which is the best tested and proven practices in scheduling. Here the recommendations of this paper are to incorporate scheduling specifications in the contract documents to comply with the best-tested practices in scheduling to produce a high quality , reliable schedule for the performance measurement of the project.

This model specification has been created that meets the criteria established by CSI in terms of formatting while incorporating the GAO standards shown in Appendix II and Appendix VI and those of the Texas DOT is shown in Appendix I.

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APPENDIX -I

MODEL PERFORMANCE SPECIFICATION FOR SCHEDULING

Introduction

The introduction is not part of the specification and the contents to be reviewed and modified before the implementation of a contract to ensure to meet the requirements.

1. Consistent terminology –In this scheduling specification, the definition of terms used is adopted from the GAO Schedule Assessment Guide. When the preparation of the contract, the definition of terms should be compatible with the GAO guide and CSI manual practices. " This specification includes a definitions section for terms used in the specification. Please check to ensure that these definitions are compatible with the definitions used in your contract. Also, please check to ensure that the terms used in the model specification are consistent with the usage in your contract. For example, this specification uses the term contract documents to describe all of the documents that make up the agreement between the parties to the contract. You may be using a different term or phrase ("plans and specifications," for example) to describe the same thing." [26]

2. "Correct identification of roles and responsibilities – This specification identifies only two parties, the owner and the contractor. In general, the contractor is given the responsibility to develop the schedule and to submit it to the owner for review and acceptance. These parties may be given different titles or assigned different responsibilities on your project. There may also be additional parties, such as a project manager, a scheduling consultant, an architect, or an engineer that needs to be integrated into the specification". [27]

3. Procedures – This specification gives an outline for the scheduling specification that needs to be considered and followed by the owner and contractor, respectively. The author covers the procedures to be followed for the scheduling preparation in a future paper. assumes a generic administrative process for implementing the scheduling specification. For example, the contractor is tasked with submitting the schedule to the owner for review and acceptance. Some owners, however, make it a policy not to accept a contractor's schedule. This specification will need to be modified to accommodate such a policy and any other differences between this specification and your project administration system.

   The specification format uses here as Master Format and the numbering system since this coding structure shows the scheduling work.The format and numbering system of CSI is the best proven and tested practices. The outline specifications in the master format can also be useful for the coordination of specifications and drawings. The outline specifications help to accomplish

[26] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and %20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf
[27] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and %20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

successfully Making product selection decisions early in the documentation process, Recording product selection decisions and code requirements, Preparing time schedules , Coordinating construction documents, Preparing the project manual. Specification template has adopted from CSI's Manual of Practice and Texas DoT and used Master format from CSI as coding structure, and it was modified to conform to GAO's "Schedule Assessment Guide- Best Practices in Project Scheduling, December 2015 GAO-16-89G

4. The scheduling specification helps us to perform both qualitative and quantitative analysis of the schedule. For qualitative as per the GAO guide in Appendix II, detailed questions with documentation and recommendations. Quantitative analysis in context to Appendix II for assessing the schedule health. Note, also, that this is a scheduling specification, not a time extension specification. This model specification does not forbid a contractor from submitting a schedule update that shows a project finishing late or describe the actions that the contractor must take if a project falls behind.

5. Scheduling Manual can be exclusively adopted the 10 Best Practices depicted in the GAO Schedule assessment guide for Best practices. The scheduling manual provides a road map for creating and maintaining a project schedule. The ten best practices in the GAO guide has explained well, and it helps owners to consider the relevant standards as specification and will give a clear understanding to contractors to create and maintain a high quality ,reliable schedule for the performance measurement and systematic project execution. The scheduling best practices are entailed with the four schedule characteristics such as Comprehensive, well-constructed, credible, and controlled as to be the GAO Schedule assessment guide. The Best Practices as follows ; Capturing all activities, Sequencing all activities, Assigning resources to all activities, Establishing the duration of all activities, Verifying that the schedule can be traced horizontally and vertically, Confirming that the critical path is valid, Ensuring reasonable total float, Conducting a schedule risk analysis, Updating the schedule using actual progress and logic and Maintaining a baseline schedule ".One of the most powerful and desirable new features of Primavera Version 6.0 is its ability to allow organizations to integrate schedules across projects and provide timely and useful reporting to senior managers concerning the progress of both their construction program as a whole and individual projects. To facilitate the most successful use of these new features, owners and contractors in a particular community or industry should establish a Scheduling Manual. In this, Scheduling Manual has adopted as GAO's Schedule Assessment Guide –Best Practices in Project Schedules, December 2015 GAO-16-89G . The purpose of this manual will be to establish a uniform and consistent standards for setting up work breakdown structures, naming and coding activities, assigning 1 cost for cost-loaded schedule, and for identifying resources for resource-loaded schedules. The manual could also establish a uniform schedule of observed holidays, winter or other seasonal shutdown periods, and other variables to help ensure consistent and reliable integration of scheduling information at the enterprise level across projects. This specification is written based on the presumption that such a manual has been developed and uses this manual to establish standards for naming and coding activities".[28]

[28] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

6. In this, the specifications provide options appendix II is an auditor's key question and documents and Appendix -VI, which is a standard quantitative measurement for assessing schedule health from GAO's Schedule Assessment Guide – Best Practices in Project Scheduling ,December 2015 GAO-16-89G .And these options constitute choices that must be identified and modified to prevent discrepancies. "In some instances, the specification provides for options. The "normal" or "typical" language is included in the specification, and the option is provided in italics in parentheses. Occasionally, additional commentary regarding a particular aspect of the specification has been included in the specification to aid in understanding or implementation. Such commentary is not intended to be part of the specification". [29]

7. "This specification does not mandate the use of Primavera software products and is not intended to be proprietary. However, certain requirements and terminology of this specification anticipate the use of Primavera PPM Version 6.0 and newer. The specification has not been checked against other scheduling software products to ensure that they will be able to meet the specified requirements. Because the model specification is not written for a particular contract or project, Primavera Systems, Inc. is not responsible for the consequences of its adoption into the contract. We urge you to review the specification carefully and seek appropriate assistance to adapt the provision to the project. Use of the Active Voice and Imperative Mood The model scheduling specification was written in the active voice. In sentences written in the active voice, someone acts on something. For example: "The owner will review the initial schedule at the first project meeting." A similar sentence in the passive voice — "The schedule will be reviewed at the first project meeting" — is unclear as to who is responsible for reviewing the schedule. This specification also makes use of the imperative mood. The imperative mood is used when the party issuing an instruction and the party receiving it are understood. In this specification, the owner is stating its requirements or directions for work to the contractor. For example, the sentence in this specification that states, "Plan and schedule the project and report progress to the owner," means, " The contractor shall plan and schedule the project and report the progress to the owner."[30] "Generally imperative mood should be maintained throughout the specification. It is the recommended method for instructions covering to perform particular tasks. In this, the verb comes the first word in the sentence, which clearly defines the action. And the imperative sentences are easily understandable and concise. For eg, "Avoid negative lags in the schedule."

100.1. Scheduling Terms.

1. "Activity: A discrete, identifiable task or event that takes time, uses resources, has a definable start and stop date, furthers the work's progress, and can be used to plan, schedule, and monitor a project.
2. Activity, Controlling: The first incomplete activity on the critical path. (Also referred to as the controlling operation.)

[29] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf
[30] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

3. Activity ID: A unique, alphanumeric identification code assigned to an activity. (It is recommended that owners and contractors in a particular industry or region adopt a standard activity numbering system to facilitate the integration of schedules across projects. This system could be tied to the standard specification formats adopted by certain industries, such as the format used by the Construction Specification Institute, the AASHTO Guide Specification, or other similar model or guide specification systems. It could also be tied to a standard work breakdown structure for work typical to the industry. The standard activity numbering system should be set forth in a Scheduling Manual that has been ratified by owners, contractors, subcontractors, and suppliers and then referenced as the standard for activity numbering in the scheduling specification.)
4. Activity Network Diagram: (Also called a pure-logic diagram.) A graphic representation of a CPM schedule that shows the relationships among activities.
5. Bar Chart: Also called a Gantt chart, a graphic representation of a schedule without relationships. A timescale appears along the horizontal axis.
6. Calendar Day: A day on the calendar, beginning and ending at midnight.
7. Completion Date, Contract: The original date specified in the contract for completion of the project or a revised date resulting from authorized time extensions. The contract may also specify completion dates for interim milestones, phases, or other portions of the project.
8. Completion Date, Scheduled: The completion date projected or forecasted by the schedule. The schedule may also project or forecast interim completion dates for milestones, phases, or other portions of the project.
9. Data Date: The first day in the Initial or Baseline Schedule and the first day for the performance of the work remaining in the Monthly Schedule Update or Revised Schedule. (May also be defined as the date from which a schedule is calculated.)
10. Duration, Original: The estimated time, expressed in workdays, needed to perform an activity.
11. Duration, Remaining: The estimated time, expressed in workdays, needed to complete an activity.
12. Holidays: Holidays observed are: (This list of holidays is typical for many public construction projects. Please revise this list to coordinate with the holiday schedule adopted by your industry.) 17 Feb; Revolution Day,19 Mar; Commemoration of the Victory over Gaddafi,1 May; May Day,4 Jun; Eid al-Fitr,5 &6 Jun;Eid al-Fitr Holiday,10 Aug;Arafat Day,11-13 Aug;Eid al-Adha ,31 Aug; Islamic New Year,16 Sep;Martyrs' Day,23 Oct;Liberation Day,9 Nov;Prophet Muhammad's Birthday24 Dec;Independence Day
13. Longest Path: The sequence of activities that establishes the scheduled completion date.
14. Milestone: An activity, with no duration, that is typically used to represent the beginning or end of the project or its interim stages.
15. Narrative Report: A descriptive report submitted with each schedule, schedule update, or revised schedule. The required contents of this report are set forth in this specification.
16. Open End: The condition that exists when an activity has either no predecessor or no successor, or when an activity's only predecessor relationship is a finish-to-finish relationship or only successor relationship is a start-to-start relationship.
17. Predecessor: An activity that is defined by schedule logic to precede another activity. A predecessor may control the start or finish date of its successor.

18. Relationship: The interdependence among activities. Relationships link an activity to its predecessors and successors. (A schedule's relationships are sometimes referred to as the logic of the schedule. Examples of relationships are: finish-to-start, start-to-start, and finish-to-finish.)
19. Schedule: Activities organized by relationships to depict the plan for the execution of a project.
20. Schedule, Initial: The schedule showing the original plan for the first 60 calendar days of work.
21. Schedule, Monthly Update: A schedule produced by incorporating the project's actual progress (sometimes known as as-built information or data) over a routine interval, usually monthly, into the Baseline Schedule or the latest Monthly Update Schedule.
22. Schedule, Revised: A schedule prepared and submitted by the contractor that includes a significant modification to the schedule logic or durations, usually for the purpose of depicting a significant change in the contractor's plan.
23. Schedule, Final: The last schedule update containing actual start and finish dates for every activity. The contractor must certify the final schedule's accuracy.
24. Successor; An activity that is defined by schedule logic to succeed in another activity. The start or finish date of a successor may be controlled by its predecessor". [31]
25. "Backward pass: A calculation in a schedule network that determines late start dates by subtracting durations from late finish dates
26. Baseline schedule: Represents the original configuration of the program plan and signifies the consensus of all stakeholders regarding the required sequence of events, resource assignments, and acceptable dates for key deliverables
27. Basis document: A single document that defines the organization of the IMS, describes the logic of the network, describes the basic approach to managing resources, and provides a basis for all parameters used to calculate dates
28. Consolidated schedule: An IMS that aggregates multiple project files in a single master file for reporting or management purposes, even if those projects are immaterially related. Also known as a portfolio schedule, although portfolio schedule and consolidated schedule are often synonymous with IMS
29. Contingency: A margin or a reserve of extra time to account for known and quantified risks and uncertainty
30. Critical activity: An activity on the critical path. When the network is free of date constraints, critical activities have zero floats, and therefore any delay in the critical activity causes the same day-for-day amount of delay in the program forecast finish date
31. Critical path: The longest continuous sequence of activities in a schedule. Defines the program's earliest completion date or minimum duration
32. Dangling logic: Scheduling logic that is not properly tied to an activity's start or end date. Also referred to as hanging logic
33. Date constraint: An override of the calculated start or finish dates of activities by imposing calendar restrictions on when an activity can begin or end

[31] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

34. Detail activity: Activities at the lowest level of the WBS representing the performance of actual discrete work that is planned in the project. Logically related paths of detail activities are linked to milestones to show the progression of work that is planned
35. Detail schedule: The lowest level of schedule. The detailed schedule lays out the logically sequenced day-to-day effort to reach program milestones
36. Deterministic critical path: The critical path as defined by the initial or current set of inputs in the schedule model
37. Duration: The estimated time required to complete an activity—the time between its start and finish. Durations are expressed in business units, such as working days, and are subjected to the project calendar
38. Finish no earlier than (FNET): A date constraint that schedules an activity to finish on or after a certain date. That is, FNET constraints prevent activity from finishing before a certain date. Also called finish on or after constraints.
39. Finish no later than (FNLT): A date constraint that schedules an activity to finish on or before a certain date. That is, FNLT constraints prevent activity from finishing after a certain date. FNLT constraints are also called finish on or before constraints
40. Finish-to-finish (F–F):A logic relationship that dictates that a successor activity cannot finish until the predecessor activity finishes
41. Finish-to-start (F–S): A logic relationship that dictates that a successor activity cannot start until the predecessor activity finishes
42. Float: See total float or free float. Also referred to as slack
43. Forward pass A calculation in a schedule network that determines the early start and early finish times for each activity by adding durations successively through the network, starting at day one. The forward pass will derive the total time required for the entire project by calculating the longest continuous path through the network
44. Fragnet: A fragmentary, or subordinate, network that represents a sequence of activities typically related to repetitive effort. Subordinate networks can be inserted into larger networks as a related group of activities
45. Free float: The portion of an activity's total float that is available before the activity's delay affects its immediate successor. Depending on the sequence of events in the network, an activity with total float may or may not have a free float
46. Giver/receiver: Represents dependencies between schedules, such as hand-offs between integrated product teams and delivery and acceptance of government-furnished equipment
47. Horizontal traceability: Demonstrates that the overall schedule is rational, has been planned in a logical sequence, accounts for the interdependence of detailed activities and planning packages, and provides a way to evaluate current status. Schedules that are horizontally traceable depict logical relationships between different program elements and product handoffs
48. Integrated master schedule (IMS) :A program schedule that includes the entire required scope of effort, including the effort necessary from all government, contractor, and other key parties for a program's successful execution from start to finish. The IMS should consist of logically related activities whose forecasted dates are automatically recalculated when activities change. The IMS includes summary, intermediate, and detail-level schedules

49. Intermediate Schedule: The intermediate schedule includes all information displayed in the summary schedule, as well as key program activities and milestones that show the important steps in achieving high-level milestones.
50. Lag: Denotes the passage of time between two activities. Lags simply delay the successor activity—no effort or resources are associated with this passage of time
51. Lead: A negative lag used to accelerate a successor activity. Leads imply the unusual measurement of negative time and exact foresight about future events
52. Level-of-effort (LOE) activity: An activity that represents an effort that has no measurable output and cannot be associated with a physical product or defined deliverable. LOE activities are typically related to management, and other oversights that continue until the detailed activities they support have been completed
53. Longest path: Theoretically, the longest path is equal to the critical path. As a schedule becomes more complex, total float values may not necessarily represent a true picture of schedule flexibility. In those cases, the longest path is the sequence of activities directly affecting the estimated finish date of the key milestone, ignoring the presence of any date constraints
54. Merge bias: The additional risk at points in the schedule where parallel paths merge
55. Milestone: Points in time that have no duration but that denote the achievement or realization of key events and accomplishments such as program events or contract start dates. Because milestones lack duration, they do not consume resources.
56. Must finish on (MFON): A date constraint that schedules an activity to finish on a certain date. That is, MFON constraints prevent activity from finishing any earlier or later than a certain date, thereby overriding network logic. MFON constraints are also called mandatory finish constraints
57. Must start on (MSON): A date constraint that schedules an activity to start on a certain date. That is, MSON constraints prevent activity from starting any earlier or later than a certain date, thereby overriding network logic. MSON constraints are also called mandatory start constraints
58. Near-critical activity: An activity with total float within a narrow range of the critical path. Near critical activities can quickly become critical if their small amount of total float is used up in a delay
59. Out-of-sequence logic: The result of progress on an activity performed in a different order from that originally planned
60. Path convergence: Several parallel activities joining with a single successor activity
61. Performance measurement baseline: A time-phased budget plan for accomplishing work. Performance is measured against the PMB
62. Predecessor: Activities that are logically related within a schedule network are referred to as predecessors and successors. A predecessor activity must start or finish before its successor
63. Probabilistic branching: The addition of new activities in a schedule that occurs only with some probability. Probabilistic branching is used to model the random choice between two alternatives
64. Progress override: When out-of-sequence progress occurs, managers and schedulers may choose to override the existing network logic. Work on the activity that began out of sequence is permitted to continue, regardless of original predecessor logic. Actual progress

in the field supersedes the planning logic, and work on the out-of-sequence activity continues

65. Resource: Anything required to perform work, such as labor, materials, travel, and facilities
66. Resource leveling: Adjusts the scheduled start of activities or the work assignments of resources to account for their availability. Leveling is used primarily by the organization that has control of the resources to smooth spikes and troughs in resource demands created by the sequencing of activities in the schedule network
67. Retained logic: When out-of-sequence progress occurs, managers and schedulers may choose to retain existing network logic. Work on the activity that began out of sequence is stopped until its predecessor is completed. As much as possible of the original network logic is preserved because the remainder of the out-of-sequence activity is delayed until the predecessor finishes, to observe its original sequence logic
68. Risk: An uncertain event that could affect the program positively or negatively. Risk and its outcomes can be quantified in some definite way
69. Rolling wave planning: The incremental conversion of work from planning packages to detailed work packages. Rolling wave planning with portions of effort that align to significant program increments, blocks, or updates is sometimes referred to as block planning
70. Schedule narrative: A document that accompanies the updated schedule to provide a log of changes and their effect, if any, on the scheduled time
71. Schedule risk analysis: An analysis that uses statistical techniques to predict a level of confidence in meeting a program's completion date. A schedule risk analysis focuses on uncertainty and key risks and how they affect the schedule's activity durations
72. Slack: A synonym for float
73. Start no earlier than (SNET): A date constraint that schedules an activity to start on or after a certain date, even if its predecessors start or finish earlier. That is, SNET constraints prevent activity from the beginning before a certain date. SNET constraints are also called start on or after constraints
74. Start no later than (SNLT): A date constraint that schedules an activity to start on or before a certain date. That is, SNLT constraints prevent activity from starting any later than a certain date. SNLT constraints are also called start on or before constraints
75. Start-to-finish (S–F): A theoretical logic relationship that has the bizarre effect of directing a successor activity not to finish until its predecessor activity starts
76. Start-to-start (S–S): A logic relationship that dictates that a successor activity cannot start until the predecessor activity starts
77. Statement of Work (SOW) :Defines, either directly or by reference to other documents, performance requirements for a contractor's effort. The SOW specifies the work to be done in developing the goods or services to be provided by a contractor
78. Status date: Denotes the date of the latest update to the schedule and thus defines the demarcation between actual work performed and remaining work. Also called a data date or time-now date
79. Statusing: The process of updating a plan with actual dates, logic, and progress and adjusting forecasts of the remaining effort
80. Successor: Activities that are logically related within a schedule network are referred to as predecessors and successors. A predecessor activity must start or finish before its successor

81. Summary activity: A grouping element that shows the time that activities of lower levels of detail required. Summary activities derive their start and end dates from lower-level activities
82. Summary schedule: Provides a strategic view of the activities and milestones necessary to start and complete a program. Summary schedules are roll-ups of lower-level intermediate and detail schedules
83. Total float: The amount of time an activity can be delayed or extended before delay affects the program's finish date. If positive, it indicates the amount of time that an activity can be delayed without delaying the program's finish date. If negative, it indicates the amount of time that must be recovered so as not to delay the program's finish date beyond the constrained date. Zero total float means that any amount of activity delay will delay the program finish date by an equal amount
84. Vertical traceability: Demonstrates the consistency of dates, status, and scope requirements between different levels of a schedule—summary, intermediate, and detailed. When schedules are vertically traceable, lower-level schedules are clearly consistent with upper-level schedule milestones, allowing for total schedule integrity and enabling different teams to work to the same schedule expectations
85. Work breakdown structure: Deconstructs a program's end product into successively greater levels of detail until the work is subdivided to a level suitable for management control
86. Work package: An activity or grouping of activities at the lowest level of the work breakdown structure, where work is planned, and progress is measured".[32]

100.2. "Administrative Requirements.

1. General Requirements.

Plan and schedule the project and report progress to the owner. Provide a schedule using the critical path method (CPM). The owner's acceptance of any schedule, whether initial, baseline, update, or revised, does not modify the contract or constitute endorsement or validation by the owner of the contractor's logic, activity durations, or assumptions in creating the schedule. By accepting the schedule, the owner does not guaranty that the project can be performed or completed as scheduled. If the contractor or the owner discover errors after the schedule has been accepted, correct the error in the next schedule submission.

2. Required Schedules.

2.1 Initial Schedule. The owner will use the initial schedule to monitor progress until the baseline schedule is accepted. Prepare and submit a schedule for the first 60 calendar days of work in accordance with subsections 3.1 and 3.2, plus a summary bar chart schedule for the balance of the project. Activity durations on the summary chart may exceed 15 working days. At least 10 calendar days before the first project meeting, submit the initial schedule to the owner. Ensure that the schedule shows milestone and completion dates no later than the specified contract milestone and completion dates. The owner will review the initial schedule at the first

[32] U.S. Government Accountablity Office. (2015). *GAO Schedule Assessment Guide Best Practices for Project Schedules*. Glossary (pp216-219).

project meeting. At this meeting, be prepared to generally discuss the proposed schedule for the entire project, not just the 60-day period covered by the initial schedule. If deviations to the staging, phasing, or sequencing required by the contract documents are proposed, be prepared to discuss these deviations. Within 5 calendar days of the first project meeting, the owner will respond by accepting the initial schedule, rejecting the schedule and identifying the reason for rejection, or by asking for more information. Address the reasons for rejection or provide the information requested and resubmit the revised initial schedule no more than 5 calendar days after the Owner's 5 response. The owner may withhold progress payments until the contractor submits the initial schedule.

2.2 Baseline Schedule. No more than 30 calendar days after approval of the initial schedule, prepare and submit a baseline schedule to the owner for review, in accordance with the requirements of subsections 3.1 and 3.2. Within 10 calendar days of receipt of the baseline schedule, the owner will respond by accepting the baseline schedule, rejecting the schedule and identifying the reason for rejection, or by asking for more information. Address the reasons for rejection or provide the information requested and resubmit the revised baseline schedule no more than 10 calendar days after the owner's response. The owner may withhold progress payments until the contractor submits, and the owner accepts the baseline schedule.

2.3 Monthly Schedule Update. Prepare and submit a monthly schedule update to the owner that depicts the status of the project as of the end of the month, in accordance with the requirements of subsections 3.1 and 3.2. The update will reflect a new data date, work performed up to, but not including, the new data date, and the plan for completing the project. Submit the schedule update by the first Monday of the following month. The owner may withhold progress payments until the contractor submits, and the owner accepts the schedule update.

2.4 Revised Schedule. The owner has the right to request a revised schedule. Circumstances leading to such a request include, but are not limited to:

2.4.1 A projected or forecasted delay to scheduled interim or project completion dates

2.4.2 A significant difference between the actual sequence or duration of work and that depicted in the schedule Prepare and submit the revised schedule no more than 10 calendar days after the owner's request in accordance with the requirements of subsections 3.1 and 3.2. Within 10 calendar days of receipt, the owner will respond by accepting the revised schedule, rejecting the schedule and identifying the reasons for rejection, or by requesting more information. Address the reasons for rejection or submit the information requested no more than 10 calendar days after the owner’s request. The owner may withhold progress payments until the contractor submits, and the owner accepts the schedule revision.

2.5 Final Schedule. Within 30 calendar days of final acceptance of the project, submit a final schedule with actual start and finish dates for each activity. Include with the submission a

certification signed by the principal of the firm stating: "To the best of my knowledge, the enclosed final schedule reflects the actual start and finish dates of the activities contained herein." [33]

100.3. "Technical Requirements.

1. Software Compatibility Requirements.

The owner uses Primavera Version 6.0 to schedule and monitor its construction program. Prepare and maintain the schedule using one of the following software options:

1.1 Primavera Version 6.0 and My Primavera, in which case the schedule is prepared and maintained on the owner's database.

1.2 Primavera Version 6.0, in which case the schedule is prepared on a separate database and maintained through file submission described below.

1.3 Primavera for Contractors in which case the schedule is prepared on a separate database and maintained through file submission described below.

1.4 Any other software that is compatible in the Primavera Version 6.0, in which case the schedule is prepared on a separate database and maintained through file submission described below.

2. Schedule Requirements. Provide a schedule that meets the following requirement:

2.1 Calculate the schedule using the Retained Logic scheduling option unless written authorization is obtained from the owner to use the Progress Override scheduling option.

2.2 Do not use the following types of logic relationships.

2.2.1 Negative lags

2.2.2 Lags in excess of 10 workdays

2.2.3 Start-to-finish relationships

2.2.4 Open ends. Only the first activity will have no predecessor, and only the last activity will have no successor.

2.2.5 Constraints. The contractor may use a limited number of constraints only with the owner's written authorization.

[33] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

2.2.6 Manually modified dates. The contractor may manually modify dates only with the owner's written authorization.

2.2.7 Obtain the owner's written authorization prior to using lags with finish-to-start relationships

2.3 Includes the following work activities, as applicable:

2.3.1 Work to be performed by the contractor, subcontractors, and suppliers.

2.3.2 Work to be performed by the owner, other contractors, and third parties such as government agencies and authorities, permitting authorities, or other entities required for completion of the project.

2.3.3 The project start date, scheduled completion date, and other contractually mandated milestones, start or finish dates for phases, or site access or availability dates

2.3.4 Submittal, review, and approval activities when applicable, including time periods for the owner's approval as specified in the contract documents (A specific contract reference is preferred here.)

2.3.5 Fabrication, delivery, installation, testing, and similar activities for materials, plants, and equipment

2.3.6 Sampling and testing periods

2.3.7 Settlement or surcharge periods

2.3.8 Cure periods

2.3.9 Utility notification and relocation

2.3.10 Installation, erection and removal, and similar activities related to temporary systems or structures such as temporary electrical systems or shoring

2.3.11 Punch list, substantial completion, final cleanup, and similar activities

2.3.12 Required acceptance testing, inspections, or similar activities

2.3.13 Durations for receipt of permits or acquisition of rights of way

2.4. Define the following attributes for each activity in the schedule:

2.4.1 A unique alphanumeric Activity ID as specified in the owner's Scheduling Manual

2.4.2 A unique descriptive name, using such attributes as work type and location to distinguish activities as specified in the owner's Scheduling Manual (This should be coordinated with a standard work breakdown structure and follow the guidelines established in the Scheduling Manual);

2.4.3 A duration stated in workdays of no more than 15 workdays unless a longer duration is requested by the contractor and approved by the owner

2.4.4 Uses codes for responsibility, phasing, and staging as specified in the Scheduling Manual

3. Schedule Submission Requirements.

3.1 Preparing Schedule on Owner's Database. If the schedule is prepared using My Primavera in the owner's database, then for each schedule submission, submit the following items:

3.1.1 A transmittal letter to the owner identifying which schedule in the database is being submitted for review

3.1.2 A narrative report

3.2 Preparing Schedule on Separate Database. If the schedule is prepared using Primavera Version 6.0, Primavera for Contractors, or some other software compatible with Primavera Version 6.0, then, for each schedule submission, submit the following items:

3.2.1 A transmittal letter

3.2.2 A narrative report

3.2.3 A Primavera Version 6.0 compatible electronic file of the schedule on a computer disc (CD)

3.2.4 The critical path in bar chart format (Longest Path sort)

3.2.5 Work paths with total float values within 20 workdays of the critical path's total float value in bar chart format. For example, if the critical path has a total float value of zero, then show all of the work paths with total float values of 20 or less.

3.2.6 An activity network diagram plotted in color, on E-size paper, with each sheet of the plot including a title, match data for diagram correlation, a page number, and a legend. The activity network diagram should only be submitted with schedules with revised relationships or activity durations.

3.2.7 A Predecessor/Successor report with the following items for each activity:

3.2.7.1 Activity ID and description

3.2.7.2 Original duration

3.2.7.3 Remaining duration

3.2.7.4 Calendar ID

3.2.7.5 Predecessors and Successors

3.2.7.6 Early start date

3.2.7.7 Early finish date

3.2.7.8 Late start date

3.2.7.9 Late finish date

3.2.7.10 Total float

3.2.7.11 Relationship type

3.2.7.12 Lags

3.2.7.13 Constraints

3.3. Narrative Reports for the Initial and Baseline Schedule. For each submission of the initial and baseline schedule provide a narrative report that includes the following information:

3.3.1 Explanation of the overall plan to complete the project, including where the work will begin and how the work and crews will flow through the project

3.3.2 Use and application of the workdays per week, number of shifts per day, number of hours per shift, holidays observed, and how the schedule accommodates adverse weather days for each month of activity

3.3.3 If the project is a multi-year project, then identify the work to be completed in each construction season

3.3.4 A statement explaining why the scheduled completion date is forecast to occur before or after the contract completion date.

3.3.5 An explanation stating why any of the contract milestone dates are forecast to occur late.

3.3.6 A description of problems or issues anticipated

3.3.7 A description of anticipated delays, including:

3.3.7.1 Identification of the delayed activity by activity ID and description

3.3.7.2 Type of delay

3.3.7.3 Cause of the delay

3.3.7.4 Effect of the delay on other activities, milestones, and completion dates

3.3.7.5 Identification of the actions needed to avoid or mitigate the delay

3.3.8 A description of the critical path

3.3.9 A description of work paths with total float values within 20 workdays of the critical path's total float value. For example, if the critical path has a total float value of zero, then describe all of the work paths with total float values of 20 or less.

3.3.9 A statement identifying constraints and an explanation of the reason for and purpose of each constraint.

3.3.10 A statement describing the status of required permits.

3.3.11 The statement describing the reason for the use of each lag.

3.4 Narrative Reports for the Monthly Schedule Update and Revised Schedule. For each submission of the monthly schedule update and revised schedule provide a narrative report that includes the following information:

3.4.1 A description of the status of the scheduled completion date (and any contract milestone date(s)) since the last schedule submitted

3.4.2 A statement explaining why the scheduled completion date is forecast to occur before or after the contract completion date. An explanation stating why any of the contract milestone dates are forecasted to occur late

3.4.3 A description of the work performed since the last schedule update

3.4.4 A description of unusual labor, shift, equipment, or material conditions or restrictions encountered or anticipated

3.4.5 A description of the problems encountered or anticipated since the last schedule submission

3.4.6 A statement that identifies and describes any current and anticipated delays. A discussion of delays in the narrative report does not constitute notice

and does not replace the need for the contractor to provide notice as required by the contract. Include the following:

3.4.6.1. Identification of the delayed activity by activity ID and description

3.4.6.2 Type of delay

3.4.6.3 Cause of the delay

3.4.6.4 Effect of the delay on other activities, milestones, and completion dates

3.4.6.5 Identification of the actions needed to avoid or mitigate the delay

3.4.7 A description of the critical path

3.4.8 A description of changes in the critical path and schedule completion date (for the project or its milestones) from the last schedule submission

3.4.9 Descriptions of the status of work paths that have total float values within 20 workdays of the critical path identified in the previous schedule submission

3.4.10 Descriptions of work paths with total float values within 20 workdays of the critical path's total float value. For example, if the critical path has a total float value of negative 25, then show all of the near-critical paths with total float values of negative 5 or less.

3.4.11 A statement or Claim Digger report that identifies the changes made between the previous schedule submission and the current proposed schedule, including, but not limited to:

3.4.11.1 Data date

3.4.11.2 Completion date

3.4.11.3 Activity code assignments

3.4.11.4 Scheduling options

3.4.11.5 Activity descriptions

3.4.11.6 Added activities

3.4.11.7 Deleted activities

3.4.11.8 Added activity relationships

3.4.11.9 Deleted activity relationships

3.4.11.10 Activity original durations

3.4.11.11 Activity remaining durations

3.4.11.12 Activity actual start and finishes

3.4.11.13 Percent complete

3.4.11.14 Constraints

3.4.11.15 Activity resources

3.4.11.16 Activity costs

3.4.11.17 Activity coding

3.4.12. A statement providing the status of pending items, including, but not limited to:

3.4.12.1 Permits

3.4.12.2 Change orders

3.4.12.3 Time extension requests

3.4.12.4 Noncompliance or similar notices are indicating deficiencies in the contractor's performance."[34]

100.4. QUALITY ASSURANCE

Quality assurance of the schedule shall conform to GAO's Schedule assessment guide –Best Practices for Project Schedules Appendix II.

100.5. WARRANTY

The schedule should give the warranty to the smooth execution of the project during the contract period.

100.6. REFERENCE

[34] Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20-%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf

24. The Construction Specification Institute. (2004). *The Project Resource Manual (PRM) : CSI Manual of Practice, 5th Edition: CSI Manual of Practice, 5th Edition*. New York, NY: McGraw Hill Professional.

25. Model Scheduling Specification; Retrieved from https://ftp.dot.state.tx.us/pub/txdotinfo/tta/ih635/addendum11/5_reference_information_documents/11%20%20studies%20and%20reports/technical%20resources/primavera%20model%20schedule%20specification.pdf
26. The United States. Government Accountability Office. Applied Research and Methods. (2015). Capturing All Activities. In *GAO schedule assessment guide: best practices for project schedules* (2015 ed., pp. 25-26). Washington DC.

APPENDIX-II

APPENDIX II

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 proj-ect schedules?
3. How does management ensure the accuracy of reported schedule information? Do the government program management office and contractors have different sched-uling software systems? If so, how is integrity preserved and verified when convert-ing the schedule?
4. Does the IMS include government, contractor, and applicable subcontractor effort?
5. Does the schedule reflect the program WBS and does the WBS allow tracking key deliverables? Does every activity trace to an appropriate WBS element, and do the activities define how the deliverables will be produced? Does the schedule WBS map to the cost estimate WBS? Is there a WBS dictionary?
6. Are key milestones identified and are they consistent with the contract dates and other key dates management established in the baseline schedule?
7. Does the schedule have clear start and finish milestones? Are there too many mile-stones in relation to detail activities?
8. Are activities within the schedule easily traced to key documents and other infor-mation through activity or task codes? Are all contractor activities mapped to the contract statement of work (SOW) to ensure that all effort is accounted for in the schedule?
9. 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")?
10. Are level-of-effort activities clearly marked?
11. Does the schedule include significant risk mitigation efforts as discrete activities? If not, how are they documented and tracked?

Key Documentation

1. Work breakdown structure (WBS) and dictionary

GAO-16-89G Appendix II 151

2. Statement of work (SOW), integrated master plan (IMP) and mission require-ments, as applicable
3. SOW crosswalk to the WBS and schedule activities, as applicable
4. Contractor WBS to program WBS crosswalk
5. Schedule custom fields and activity codes dictionary and LOE field identification
6. Activity codes used to organize and filter the activities into categories as necessary to confirm a complete scope of work
7. Plans and documentation used for defining activities, such as the systems engineer-ing plan, software development plan, risk management plan, and master test plan.

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 activities are not accounted for, it is uncertain whether all activities are sched-uled 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 program members' incomplete understanding of the plan and its progress toward a successful conclusion.
3. If the schedule does not fully and accurately reflect the program, 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 coordi-nation efforts, increasing the likelihood of disruption and delays.
6. If the schedule is not planned in sufficient detail, then opportunities for process improvement (for example, identifying redundant activities), what-if analysis, and risk mitigation will be missed.
7. A schedule that does not emanate from a single start milestone activity and ter-minate at a single finish milestone activity is not properly constructed and may produce an erroneous critical path.
8. LOE activities can interfere with the critical path unless they are clearly marked and represented as summary or hammock activities designed for the purpose.
9. Too many milestones in the schedule can mask the activities necessary to achieve key milestones and can prevent the proper recording of progress.
10. 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 diffi-cult to manage progress.
11. Unless the schedule is aligned to the program WBS, management cannot ensure that the total scope of work is accounted for within the schedule.
12. Repetitive naming of activities makes communication difficult between teams, par-ticularly 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 program?
2. Are the majority of the relationships within the detailed schedules finish-to-start?
3. Are predecessor links (with the exception of the start milestone) or successor links (with the exception of the finish milestone) missing?
4. Are any predecessors or successors dangling?
   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 effect on the project) have an F–S or F–F successor that it drives?
5. Do summary activities have predecessor or successor links?
6. Do activities have start-to-finish links?
7. How much convergence (that is, several parallel activities converging at one major event) is there in the schedule? For activities that have many converging predeces-sors, do those predecessors have adequate float?
8. Does the schedule contain date constraints other than "as soon as possible"? Is each one justified in the schedule documentation?
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. Documentation justifies using hard and soft date constraints instead of activities' duration and logic.
2. Documentation justifies using lags and leads instead of activities' duration and logic.
3. Documentation justifies 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 criti-cal path. If the schedule is missing dependencies or if activities are linked incorrect-ly, 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 links, activities that slip early in the schedule do not transmit delays to activ-ities that should depend on them. When this happens, the schedule will not allow a sufficient understanding of the program as a whole, and users of the schedule will

GAO-16-89G Appendix II 153

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 realistic workflow. If logic between activities is miss-ing, program team members can misunderstand one another, especially regarding receivables and deliverables.
4. For scheduling software packages that include the option, summary activities should not have logic relationships because their start and finish dates are derived from lower-level activities. Summary logic hinders vertical traceability by obstruct-ing the logic of lower-level activities.
5. A start-to-finish (S–F) link has the bizarre effect of directing a successor activity not to finish until its predecessor activity starts, in effect reversing the expected flow of sequence logic. The use of S–F logic is counterintuitive and overcomplicates sched-ule network logic.
6. 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.
7. 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 the effects on the program's planned finish date from, among other things, misallocated resources, delayed activities, external events, and unrealistic deadlines.
8. Because a logic relationship dictates the effect of an on-time, delayed, or accelerated activity on following activities, any missing logic relationship is potentially damag-ing to the entire network.
9. 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.
10. 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 both progress and delays in the schedule.

11. 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.
12. 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 program and can be used to track progress toward important program milestones. Schedules with constrained dates can portray an artificial or unrealistic view of the program plan.
13. Constraints should be used only when necessary and only if their justification is documented because they override network logic and restrict how planned dates re-spond to accomplished effort or resource availability. The presence of 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.
14. 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.
15. Applying constraints to represent the availability of resources requires constant man-ual upkeep of the schedule.
16. 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 predeces-sor activities or to slip in response to delayed predecessors or longer-than-scheduled durations.
17. 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.
18. Lags must be justified because they may represent work or delay that may be vari-able 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.
19. Constantly updating lags manually defeats the purpose of a dynamic schedule and makes it particularly prone to error.
20. Using a lag with F–S logic is generally not good practice because it is generally not necessary. When it is, every effort should be made to break activities into small-er tasks and to identify realistic predecessors and successors so that logic interface points are clearly available for needed dependency assignments.
21. Leads are generally not valid. As negative lags, leads imply the unusual measurement of negative time and exact foresight about future events.
22. Using lags as buffers or margin for risk between two activities should be discouraged because the lags persist even as the actual intended margin 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, as labor categories, organizations, or individual names)?
2. Are significant material and equipment resources described in the schedule?
3. Do summary activities or milestones have resource assignments?
4. How were resource estimates developed for each activity?
5. Has analysis ensured that resources are sufficient and available in each work period when needed?
   a. Is obtaining scarce resources to accomplish the work potentially difficult?
   b. Are more resources required than are available for some work periods? 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 program cost estimate?

Key Documentation

1. Basis of estimates for resource assumptions that align with resource estimates within the cost estimates.
2. A resource allocation planning document that defines resource profiles and tables for unique resources derived from the schedule.
3. Resource output from scheduling software across all project schedules.

Likely Effects If Criteria Are Not Fully Met

1. Information on resource needs and availability in each work period assists the pro-gram office in forecasting the likelihood that activities will be completed as scheduled. If the current schedule does not allow insight into the current or projected allocation of resources, then the risk of the program's slipping is significantly increased. Overal-located resources result in inefficiency (for example, staff are less productive because of extended overtime) or program delay from unavailable resources.
2. Resources must be considered in the creation of 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 accuracy falsely.
5. Unrealistic peaks 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 quantity of resources and funding required at the peak is unrealistic.

6. If resource leveling causes enormous delays in the program finish date—for exam-ple, 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 ac-complished 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 sched-ule will convey a false sense of precision and confidence to senior decision makers.
9. A schedule that has not reviewed and resolved resource use issues is not reliable.
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 mon-itor crew productivity, allocate idle resources, monitor resource-constrained activi-ties, 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 program execution?
3. Are activities long in duration because of LOE or rolling wave planning?
4. Are LOE activity durations determined by the activities they support?
5. Did the person responsible for the activities estimate their durations?
6. Was the program duration determined by some target or mandated date?
7. Are durations based on appropriate calendars? Do any specific conditions neces-sitate special calendars, and are they addressed (for example, religious holidays, nonwork periods for climate, shift work, unavailability of resources)?
8. 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 exces-sive 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 re-sources 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 program delivery dates and unreliable critical paths and could mask program risks.
6. Proper use of resource and task calendars usually precludes the need for soft con-straints in schedules. But improperly defined task or resource calendars incorrectly represent the forecasted start, finish, and durations of planned activities. Ensuring realistic calendars provides for more accurate dates and may reveal opportunities to advance the work.
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.

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. Has horizontal traceability been demonstrated by observing the effects of delaying an activity by many days within the schedule or a similar shock to the network?
4. Are the key dates consistent between lower-level detailed working schedules and high-er-level summary schedules? Do all lower-level activities roll up into higher WBS levels?
5. Do major milestones map between the schedule and management documents and presentations?

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 demon-strated.

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.
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 program 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. 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.
6. Unless the schedule is vertically traceable, lower-level schedules will not be con-sistent with upper-level schedule milestones, affecting the integrity of the entire schedule and the ability of different teams to work to the same schedule expecta-tions.

Best Practice 6: Confirming That the Critical Path Is Valid

Key Questions

1. Is the critical path, or longest path (in the presence of date constraints), calculated by the scheduling software valid?
   a. Are any activities in the schedule missing logic or constrained without justifi-cation? Are these issues resulting in an unreliable critical path?
   b. Is the critical path a continuous path from the status date to the major com-pletion milestones?
   c. Does the critical path start with a constraint so that other activities are un-important 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 ac-tivities of unusually long duration that are not considered planning packages?
   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 detrimentally affect key program milestones and deliveries if they slip?

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 mile-stones, 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. Without a valid critical path, management cannot focus on activities that will detri-mentally affect the key program milestones and deliveries if they slip.
2. Unless 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 effects on downstream work.
3. Successfully identifying the critical path relies on capturing all activities (Best Prac-tice 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).
4. 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.
5. LOE activities should not drive the schedule. If LOE is critical, management has no indication of which activities can slip and which will respond positively to addition-al resources to reduce the risk of finishing late.
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 that 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 monitored? Does management have a plan to mitigate negative total float?
4. Does management rely on free float to level resources or reassign resources to assist critical activities?

Key Documentation

The program team can use a list of activities sorted by their total float values to deter-mine whether the total float values correctly reflect flexibility in the program schedule.

Likely Effects If Criteria Are Not Fully Met

1. If the schedule is missing activities or dependencies or if it links activities incor-rectly, float estimates will not be accurate. Incorrect float estimates may result in an invalid critical path and an inaccurate assessment of program completion dates. In addition, inaccurate values of total float falsely depict true program status, which could lead to decisions that may jeopardize the program. For example, if activities are not linked correctly to successors, total float will be greater than it should be.
2. 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.
3. 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, mak-ing target dates infeasible. The program may have to take some corrective action or the negative float may act as a threat to the program end date.
4. Too little float built into the schedule may indicate insufficient time to recover from delay without the program's completion date slipping.

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 optimistic, most likely, and pessimistic 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 magni-tude of effect?
3. Are the SRA data, assumptions, and methodology available and documented?
4. Are the probabilities and impact ranges reasonable and based on information gath-ered from knowledgeable sources? Is there evidence of bias in the risk data?
5. How is the use of schedule contingency controlled and authorized?
6. Is an SRA performed periodically to reflect actual progress and changes in risks?

Key Documentation

1. A risk register with prioritized risks.
2. SRA documentation that includes assumptions, methodology, data, data normaliza-tion techniques, and findings.
3. A listing of people interviewed or included in risk interviews along with their orga-nizations, positions, and expertise.
4. The schedule risk analysis file.

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 program'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 program,
   d. the paths or activities that are most likely to delay the program.
2. Because activity durations are uncertain, the identity of the true critical path is unknown unless a schedule risk analysis has been performed. An SRA can identify the paths that are most likely to become critical as the program progresses so that risk mitigation can lessen the effect of any delays.
3. Unless a statistical simulation is run, calculating the completion date from sched-ule 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 valid, the program's schedule must reflect reli-able logic and clearly identify the critical path. If the schedule does not follow best practices, confidence in the SRA results will be lacking.
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 criti-cal path duration may be underestimated.

Best Practice 9: Updating the Schedule Using Logic and Progress

Key Questions

1. Is progress recorded regularly? Has the schedule been updated recently as planned? Is the status date recorded?
2. Is at least one in-progress activity critical?
3. Do any activities have start or finish dates in the past without actual start or finish dates? Do any activities have actual start or finish dates in the future?
4. Is responsibility for changing or statusing the schedule assigned to someone who has the proper training and experience in CPM scheduling?

5. Were any activities started or completed out of sequence? If so, was the logic re-tained, or did the scheduler use progress override?
6. Does a schedule narrative accompany each status update and include the following?
   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 time;
   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. a description of any significant scheduling software options that changed be-tween update periods, such as the criticality threshold for total float, progress override versus retained logic and whether resource assignments are progressed along with duration.
7. Is the schedule structure examined after each update to ensure that no logic is miss-ing, constraints are necessary, and no activities impede the ability of the schedule to dynamically forecast dates?

Key Documentation

1. The schedule narrative.
2. The schedule shows actual and planned dates, remaining duration for in-process activities, and the status date.
3. Copies of program management review (PMR) briefings are available 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 comple-tion 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 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 com-pleted, 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 program 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. An out-of-sequence activity causes degradation of the schedule and requires ad-dressing. 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 realis-

tic plan to complete the program, 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 con-straints or external dependencies are separating successor activities 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, program staff might continually revise the schedule to match performance, hindering the program manager's insight into the true performance of the program. 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 prob-lems 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 programs will not be available. If sufficient attention is paid to recording the way work is performed, the resulting archived data will help improve the accuracy and quality control of future similar programs.

Best Practice 10: Maintaining a Baseline Schedule

Key Questions

1. Is the baseline schedule the basis for measuring performance?
2. Does a schedule basis document exist? Does the document
   a. describe the general approach to the program?
   b. describe the overall structure of the IMS, including the scope and purpose of projects, staff responsible for each project, the relationship between projects, a WBS dictionary, the status delivery dates for each project, and a list of key hand-off products and their estimated dates?
   c. describe the settings for key options for the scheduling software?
   d. provide an overview of the assumptions and ground rules, including justification for calendars and any lags, constraints, or long activity durations?
   e. Provide an appropriately detailed rationale for the basic approach to estimating key activity durations and justification of the estimating relationship between duration, effort, and assigned resource units?
   f. contain a dictionary of abbreviations, acronyms, and custom fields?
   g. describe the use of resources within the schedule?
   h. describe the critical risks prioritized in a schedule risk analysis as well as sched-ule contingency?
   i. 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 sched-ule change control process?
4. Is trend analysis performed, such as monitoring start and finish dates, available float, and available schedule contingency?

Key Documentation

1. The designated baseline schedule.
2. A description of the schedule change control process.
3. The current schedule change control log.
4. The schedule basis document.

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 results, thereby con-tributing 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 sched-ule. 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 reliable.
4. If changes are not controlled and fully documented, performance cannot be accu-rately measured against the original plan. Undocumented or unapproved changes will hamper performance measurement and may result in inaccurate variance re-porting, 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

APPENDIX VI

Standard Quantitative Measurements for Assessing Schedule Health

An assessment of schedule best practices encompasses both qualitative and quantitative information. Qualitative information is provided by program questions such as those detailed in appendix II. 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 analysis of the schedule data to determine the overall health of the network. While the questions addressed by the data analysis are also covered in appendix II, the quantitative assessment often involves filters and detailed data metric definitions. These filters and definitions are in table 11 for each best practice.

No "pass-or-fail" thresholds or tripwires are associated with the measures. Measures are evaluated in context with qualitative program information and any documented justification. Moreover, severity of the errors or anomalies takes precedence over quantity because any error can potentially affect the reliability of the entire schedule network.

Table 11: Standard Data Measures for Schedule Best Practices

Best practice	Measure	Note
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 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 actual start and finish dates 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, one or two detailed activities per milestone is probably a very low level of detail, while 10 is probably highly detailed

GAO-16-89G Appendix VI 183

Best practice	Measure	Note
	Number of activities not mapped to program or contractor work breakdown structure	
	Number of contractor activities not mapped to a SOW 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
2. Sequencing all activities	Best Practice 2 includes more advanced measurements to assess the reliability of the network logic. Thresholds for measures are not provided because, in theory, any missing or inappropriate logic may disrupt the entire network. The assessment of this best practice is related to 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 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 understanding the implications of constraints and incorrect or missing logic. All activities in a schedule, regardless of detail or planning period, are subjected 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; activities that have actually started may be excluded because their start dates have been determined
Dangling activities: number of remaining detail activities and milestones with no successor off 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

Percentage of logic links that are finish-to-start	The majority of relationships within a detailed schedule should be finish-to-start
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 may 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 zero or low float have the ability to delay the successor when they are delayed
Remaining detail activities and milestones with soft date constraints	

Best practice	Measure	Note
	Remaining detail activities and milestones with hard date constraints	
	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 number is different 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 number is different 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 number is different 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 number is different 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 measures and trends may be investigated for fully resource loaded schedules. If possible, resource assignments over time may be evaluated to identify potential unrealistic peaks. 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.
	Summary activities and milestones with assignments	Summary activity durations depend on the activities contained within them. Milestones should never be assigned resources because they have no duration

	Remaining detail activities with assignments	Exclude nonapplicable activities such as planning packages and reference activities
	Remaining detail activities without assignments	

GAO-16-89G Appendix VI 185

Best practice	Measure	Note
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
	Remaining detail activities or milestones starting or finishing on a weekend or holiday	May be legitimate but may stem from incorrect calendar assignments or specifications. Milestones on weekends or holidays should be questioned
	Holidays and other exceptions by task calendar	
	Remaining detail activities with durations less than the reporting period	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 the reporting period	
	Average duration of remaining detail activities	
	Median duration of remaining detail activities	
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 activities fall within the same time as higher-level activities and whether detailed schedule dates fall within the same time as summary schedule dates. An essential check of vertical traceability is determining whether forecasted milestone dates in detailed schedules match those quoted in management documents. 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 by 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 and reasonable available float
6. Confirming that the critical path is valid	Best Practice 6 has several standard measurements for assessing the validity of a 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. 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 longest path and critical path are the same to the key milestone. The path should be continuous from the status date to the key milestone

Number of critical activities	In general, if the ratio of critical path activities to the total remaining activity count is nearly 100 percent, then the schedule may be overly serial and resource limited
Number of critical LOE activities	A critical path cannot include LOE activities because they do not represent discrete effort
Number of lags and leads on the critical path	Lags cannot represent work and cannot be assigned resources
Number of critical activities with hard date constraints	Using hard constraints to fix activity dates at certain points in time immediately convolutes critical path calculations and defeats the purpose of CPM scheduling

186 Appendix VI GAO-16-89G

Best practice	Measure	Note
	Number of in-progress critical activities	Given that the critical path is a continuous sequence of activities from the status date, at least one in-progress activity is critical
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 produces reasonable estimates of float and a valid critical path. 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 should realistically reflect the flexibility of the schedule
	Remaining detail activities with negative total float	Negative total float indicates that the activity's constraint date is earlier than its calculated late finish. Negative float may occur 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 II. The measures 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 optimistic, most likely, and pessimistic 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 depends on the status date reported in the schedule. It also depends on the scheduling software used: some software packages allow date anomalies that other software packages prevent	
	Number of in-progress activities	An activity is in progress when it has started but is not yet complete
	Number of remaining detail activities and milestones that have a forecasted start date in the past but no actual start date	Forecasted start dates should not occur in the past—i.e., any time preceding the status date
	Number of remaining detail activities and milestones that have a forecasted finish date in the past but no actual finish date	Forecasted finish dates should not occur in the past—i.e., any time preceding 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—i.e., any time following 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—i.e., any time following the status date
	Number of detail activities performed out of sequence	

GAO-16-89G Appendix VI 187

Best practice	Measure	Note
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 forecast to start early over the next 60 days or activities that have actually finished late over the past 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	
	Number of detail activities and milestones with baseline dates	Counts should accord with rolling wave planning periods
	Number of detail activities and milestones without baseline dates	
	Number of remaining detail activities and milestones that are forecast to start or finish before their baseline dates	Represents activities and milestones forecast to begin or end early
	Number of remaining detail activities and milestones that are forecast to start or finish on their baseline dates	Represents activities and milestones forecast to begin or end on time
	Number of remaining detail activities and milestones that are forecast to start or finish after their baseline dates	Represents activities and milestones forecast to begin or end late
	Number of remaining detail activities that actually started before their baseline start date	Represents activities and milestones that actually started early

Number of remaining detail activities that actually started on their baseline start date	Represents activities and milestones that actually started on time
Number of remaining detail activities that actually started after their baseline start date	Represents activities and milestones that actually started late
Number of detail activities and milestones that actually finished before their baseline finish date	Represents activities and milestones that actually finished early
Number of detail activities and milestones that actually finished on their baseline finish date	Represents activities and milestones that actually finished on time
Number of detail activities and milestones that actually finished after their baseline finish date	Represents activities and milestones that have actually finished late

Average and median start variance	Start variance may be the difference between actual start and baseline start or forecast start and baseline start
Average and median finish variance	Finish variance may be the difference between actual finish and baseline finish or forecast finish and baseline finish
Baseline execution index	The ratio of actual completed detail activities to detail activities that were planned to finish. A BEI of 1 indicates that the project is performing according to plan. A BEI less than 1 indicates that, in general, fewer activities are being completed than planned; a BEI greater than 1 indicates that, in general, more activities are being completed than planned

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188 Appendix VI GAO-16-89G

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