

Depicting Schedule Margin in Integrated Master Schedules

National Defense Industrial Association

Program Management Systems Committee

Schedule Working Group

FORWARD

The objective of this paper is to discuss practices for depicting Schedule Margin in Integrated Master Schedules and project schedules and to induce collaboration between government and industry for revising related guidance and direction to incorporate these best practices. The desired output of this collaboration is agreement on schedule margin practices acceptable to all stakeholders. The scope of the discussion is limited to the techniques of depicting Schedule Margin in program and project schedules. In the interest of bounding this discussion, this white paper addresses the two most common methods to depict Schedule Margin in the schedule, which are the use of buffer tasks and the creation of deadlines that are earlier than contractual milestones. Techniques for quantifying Schedule Margin are referred to when they are germane to the topic but are not the focus of this paper and are discussed only as necessary.

Terms used interchangeably in this paper: Schedule Margin and Schedule Reserve.
Integrated Master Schedule (IMS) and Schedule
Program and Project

BACKGROUND

The schedule margin concept has been applied in one form or another since Henry Gantt invented the Gantt Chart however, the attempt to institutionalize within the federal acquisition community is more recent. As the formal identification of schedule margin in projects and programs increases, questions have been raised regarding the appropriate method of depicting schedule margin as either a task with duration but no scope or resources or as the delta between a risk-adjusted deadline and a specified contractual constraint (milestone). Opinions often depend on the objectives of the project's various stakeholders and the purpose of the schedule.

Project Managers use the schedule as a management tool that facilitates effective management and control of a project or program. Other stakeholders (including customers and oversight organizations) use the schedule as a means to verify the realism and efficacy of the project plan. Project management professionals recognize that schedule margin is an effective risk mitigator and is used to manage and control the project. However, some organizations and professionals have a differing view and assert that schedule margin should be identified as

deadlines in front of contractual milestones (constraints). A literature search found that the primary source of guidance on schedule margin was in the Federal Government, specifically NASA and the DoD, which have differing views of schedule margin.

THE PROJECT SCHEDULE (INTEGRATED MASTER SCHEDULE)

The schedule is a plan that for how the project will deliver its products and capabilities to the customer. This primary purpose provides the project manager a key tool for management and control of resources and work. Because plans are not perfect, the schedule is a living plan that evolves as a consequence of change, which is a constant in all projects. Managing this change with respect to the program baseline is essential.

The Office of the Secretary of Defense (OSD) Acquisition, Technology, & Logistics (AT&L) *Integrated Master Plan and Integrated Master Schedule Preparation and Use Guide* provides the following view of the schedule:

A comprehensive IMS used to manage the program on a daily basis. It is normally provided by the contractor via a Contract Data Requirements List (CDRL) item. It is updated on a regular basis. It should contain all of the contract IMP events, accomplishments, and criteria from contract award to completion of the contract . . . [Page 5]

It is clear that OSD AT&L recognizes that the integrated master schedule (IMS) is a tool used by project managers to help manage and control the project. The schedule tells them what they need to do every day; what is important; what resources must be applied and when. The schedule helps them make decisions when faced with unplanned events that affect the project. Without the visibility the provided by the schedule, the project manager can only guess what to do and how to react to unplanned events and ill-structured problems that arise.

The schedule does have a second purpose in that it is an artifact that documents and demonstrates the adequacy of the project planning and, when routinely statused, the performance of the project against the plan. The schedule is commonly provided to internal and external stakeholders and customers who analyze the schedule to provide confidence in the plan and assurance of satisfactory performance against the plan.

Stakeholders influence the schedule by establishing constraints such as major milestones that reflect the project objectives and through specific format and content requirements for the schedule such as is contained in *DI-MGMT-81650, Integrated Master Schedule*.

It is necessary and vital for stakeholders, especially the federal government, to exercise oversight and insight into the contractor's planning, management, and performance. However, the responsibility for the planning and management resides with the contractor including company practices for identifying Schedule Margin in the IMS.

SCHEDULE MARGIN

Schedule Margin is a management tool to mitigate the consequences of imperfect planning and execution. With perfect knowledge and foresight, a project manager could identify all the tasks, resources, interfaces, external events, interdependencies, and even predict future conditions that would facilitate the creation of a perfect schedule. Of course, knowledge is imperfect and highly accurate forecasting, especially in multiyear projects is impossible. Consequently, schedules account for imperfection through the identification of risks, schedule risk analysis, and the inclusion of Schedule Margin in the integrated master schedule to plan for schedule perturbations due to unforeseen, in-scope issues.

Schedule Margin is identified and controlled blocks of time inserted into the network of program schedules to facilitate achieving program objectives and contract requirements. Schedule Margin protects the critical path in a schedule. It is used to accommodate unforeseen in-scope issues that have the potential to threaten achievement of program objectives if not properly and proactively addressed. Schedule Margin is expressed in the same units of time as the activities/tasks.

Schedule Risk Assessments (SRAs) and Schedule Margins are closely related as the SRA helps to assess whether the schedule margin is sufficient for the defined risk associated with a given project. An SRA is employed to predict the probability of project completion within the constraints established for a project. An SRA is conducted at the beginning of a project and periodically throughout the project lifecycle. Three-point duration estimates (best case, worse case, and most likely) are provided for tasks or activities in the schedule. For large projects, estimates may not be accomplished for all activities, but at a minimum should be conducted for activities on the critical path and for all high-risk activities in the program. The result is the probability of successfully meeting the schedule dates and the key (contractual) project dates. Project staffs use these estimates to insert Schedule Margin (including buffers) to control change to the critical path and increase the likelihood of completing the project on time

Depicting Schedule Margin in the IMS is a consequence of the management process that the performing organization determines is necessary to effectively manage schedule risk. In projects and programs where there is significant complexity and concurrency, the critical path should be protected to promote program stability. For these types of projects and programs, Schedule Margin should be identified and depicted as defined buffer tasks. In less complex projects with fewer dependencies and concurrent activities, Schedule Margin may be consolidated into early milestones in advance of contractual milestones. The decision to employ one or both methods is a result of an organization's business and management practices as well as the complexity and risk in a project.

DEPICTING SCHEDULE MARGIN AS A BUFFER TASK

The critical path in a schedule is based upon the durations, constraints and relationships for all activities when the schedule is initially developed. As the work progresses some activities may take longer than planned (for a number of reasons); but few activities, if any, will be shorter than planned. Additionally, activities yet to occur may be replanned as an outcome of analysis, performance information, or natural changes in every program. As the durations change, the critical path and critical path length may change. The change in the critical path then affects downstream milestones, which in turn may cause change to upstream activities to compensate. The consequence of this change is a constant challenge to adjust activities and durations to fit within the constraints and compensate for critical path changes. The result often resembles an analog feedback loop creating an oscillation effect where change causes still more change ("today's critical path is..."). This Critical Path volatility causes more risk due to shifting resources, management attention, budgets, and the ripple effect on the remaining schedule. This volatility can be managed by analyzing the schedule through Schedule Risk Analysis and establishing buffer tasks either in the critical path or on near-critical path nodes before they enter the critical path thus protecting the critical path from change and promoting program stability. The use of buffer tasks reduces schedule risk and increases schedule stability, as shown in Figure 1

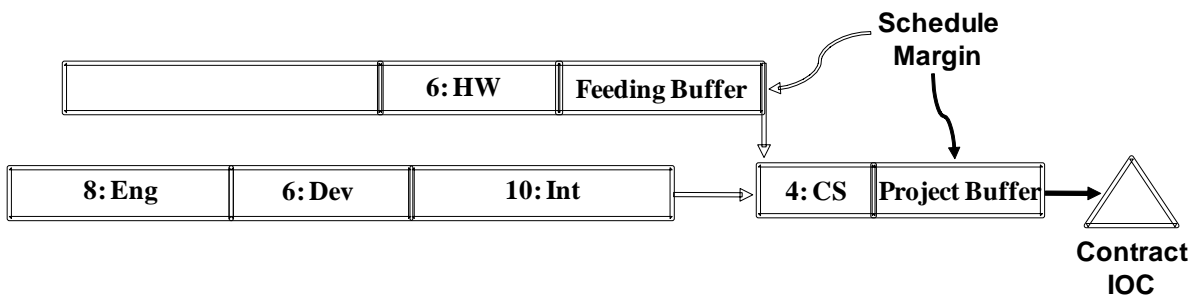


Figure 1 Project Schedule Placement of Schedule Margin in Feeding and Project Buffers

Depicting Schedule Margin as an explicit activity/task has significant benefits in that margin is readily identifiable; as such, it is directly manageable and Program Management (PM) "ownership" can be maintained or selectively delegated. If excluded from the margin activity/task duration, Schedule Margin effectively is "lost" to Control Account Managers (CAMs) and relegated to the Total Float/Slack value. The explicit buffer process also provides the ability to monitor margin erosion (per *DI-MGMT-81650, 2.4.1.23.2*). Rather than Schedule Margin being invisibly included in the Total Float/Slack value, buffer tasks provide immediate visibility in

the movement of a path's end date. This visibility permits overt action to reconcile potential impacts to schedule and promotes intervention with smaller schedule perturbations. The use of buffer tasks easily can be "converted" to Total Float by zeroing-out duration of margin nodes prior to performing Schedule Risk Assessments (SRAs).

DEPICTING SCHEDULE MARGIN USING MILESTONES

Early constraint milestones that recognize critical path uncertainty and risks also may be used at key points prior to contractual or other constraining milestones to create a buffer to ensure that these milestones can be met. Planning schedules that aggressively schedule activities at the lower end of the confidence interval establish Schedule Margin using the time difference between the planned finish date and the contractual finish date as a reserve. This should be accomplished using analytical techniques to ensure that there is a rational basis for the finish dates. This use of the best-case schedule would not contain any buffer tasks because the reserve/margin would be depicted by the difference between the planned milestone and the contractual milestone as shown in Figure 2.

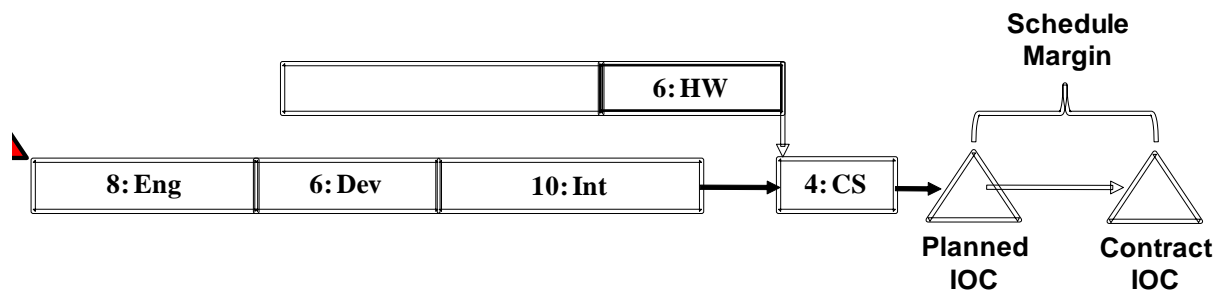


Figure 2 Project Schedule Placement of Schedule Margin Using Milestones

A schedule using the milestone margin method also may incorporate early incremental milestones. When contractual milestones are relatively few, Schedule Margin created using the difference between planned milestones and contractual milestones, while adequate, is not as managerially effective as a schedule with margin created using buffers. One of the detrimental aspects of using the milestone method against contractual milestones is the excessive use of constraints in the schedule.

ACCOMMODATING SCHEDULE MARGIN IN SCHEDULE PERFORMANCE ANALYSIS

Schedule performance analysis is a key activity in project management for both the performing organization and the stakeholders. While analytical software tools facilitate analysis, the analysis itself is conducted by human beings who interpret and analyze data and information. The project manager needs to analyze the schedule to assess the adequacy of resources and budgets; to assess progress and performance and take action when warranted; to re-plan when

there are unanticipated impacts to the project; and to conduct “what if” scenarios in order to respond to risks and opportunities. In short, the schedule is the primary planning and management tool in the project manager’s arsenal and is vital to exercising reflective judgment on complex acquisition projects. Once developed, validated, and in use, schedule performance analysis becomes the primary purpose for, and use of, the schedule.

Without the insight provided by clearly identifying remaining schedule margin, critical path analysis, margin analysis, and others types of analyses contain unquantifiable uncertainty. *Safety time that is embedded in individual Control Account Manager’s (CAM) task durations (equivalent to hidden Schedule Margin) makes it nearly impossible to make solid analytical decisions because such hidden margin cannot be removed prior to performing Schedule Risk Analysis (SRA).*

The visibility into Schedule Margin for analysis has many advantages over analysis where the margin is not visible. While the usefulness of visible Schedule Margin buffer tasks is evident, there are methods of excluding buffer tasks when analyzing the schedule. One method would be to set all buffer task durations to zero. Another would be to filter out buffer tasks. The key benefit of visible buffers in schedule analysis is that it contributes to better analysis, control, and management. Additionally, Schedule Margin easily can be zeroed prior to performing Schedule Risk Analysis (SRA).

FEDERAL GOVERNMENT REFERENCES TO SCHEDULE MARGIN

Schedule Margin as defined by National Aeronautical and Space Administration (NASA) and the Department of Defense (DoD) have some differences. Their methods are described below.

National Aeronautics and Space Administration

Margin as defined by the NASA Space Flight Program and Project Management Requirements, NPR 7120.5:

The allowances carried in budget, projected schedules, and technical performance parameters (e.g., weight, power, or memory) to account for uncertainties and risks. Margin allocations are baselined in the formulation process, based on assessments of risks, and are typically consumed as the program/project proceeds through the life cycle.

The *NASA Schedule Management Handbook, NASA/SP-2010-3403 (January 2010)* also discusses schedule margin in 5.7 Schedule Margin Planning

...The preferred technique for including schedule margin in the IMS is to insert additional tasks that are specifically identified as "Schedule Margin." These tasks should have durations assigned that provide the additional quantity of time deemed necessary to absorb the impacts of unknown schedule risks. Schedule margin must be inserted into the IMS at strategic locations so that it satisfies its intended purpose as overall schedule management margin for the project completion. To ensure this, it is recommended that this type margin be placed at the end of the IMS network logic flow just prior to hardware delivery or whatever the appropriate project completion task/milestone might be. Other example locations for this type of margin might include placement just prior to PDR and CDR. Only by clearly identifying the amount and location of schedule margin within the schedule can its use be tracked and managed adequately.

An alternative technique for managing schedule margin involves the use of milestones, constraint dates, and relationship lag values. For example, suppose there is a programmatic or contractual event commitment of concern (typically the project completion point, hardware delivery, launch, etc.). This event may be entered as a milestone in the IMS with a "Finish No Later Than" (FNLT) constraint which specifies the hard commitment date. Another companion milestone, which references the same event, may be entered as a predecessor to this event with no constraint and is labeled as the "target" for the event. The interdependency relationship connecting the two milestones should also include a specified lag value. The specified lag value represents the amount of schedule margin that is considered necessary by the project team...

The *NASA Schedule Management Handbook* also discusses the identification of schedule margin in the schedule in section 7.7, *Schedule Margin Assessment*:

Adequate schedule margin appropriately placed in a project schedule is critical to project success. A probabilistic schedule risk assessment is highly recommended as a basis for determining adequate schedule margin. Schedule margin should be easily identifiable and strategically placed within the IMS. Generally, it is recommended to create specially labeled tasks for schedule margin and place the bulk of margin at the end of the schedule just prior to project completion so that it will be reflected and easily accounted for and managed as part of the critical path sequence. Other smaller blocks of schedule margin could also be associated with significant key events in the IMS and placed logically just prior to those events.

It is also related to critical path in 7.2.3, *Critical Path Identification and Analysis*:

The schedule may become very dynamic during the implementation phase, and because of this, it is imperative to always know what sequence of tasks is the real driver affecting project completion. It is also important to monitor the

consumption of schedule margin that may exist as part of the critical path. Management insight into the critical path is essential in making accurate resource and manpower decisions to successfully achieve project completion.

The above extracts make clear that NASA intends for schedule margin to be specifically identified as a task with durations, but without defined scope, in the schedule and to be included when the critical path is calculated.

Department of Defense

In the Department of Defense, Schedule Margin is primarily discussed in *DI-MGMT-81650, Integrated Master Schedule* paragraph 2.4.1.22, which states that Schedule Margin is:

. . . a management method for accommodating schedule contingencies. It is a designated buffer and shall be identified separately and considered part of the baseline. Schedule margin is the difference between contractual milestone date(s) and the contractor's planned date(s) of accomplishment.

DI-MGMT-81650 defines Schedule Margin as a designated *buffer* and stipulates that it be considered part of the baseline. One could infer that an activity/task could be a designated buffer. However, the second part of the definition identifies Schedule Margin as the difference between contractual milestone dates and the contractor's planned date of accomplishment. This implies that margin is a period between two milestones that is simply white space rather than a named element (such as a buffer task). Either method would result in acceptable margin. For some agencies, the milestone method is preferred so that margin always appears in the same way and the same location. This ambiguity in *DI-MGMT-81650* has contributed to the debate regarding the appropriate methods for depicting schedule margin in the integrated master schedule.

CONCLUSIONS

The method of depicting schedule margin employed by a particular project must be based upon the established recommended and best practice project methodology and process employed by the performing organization in order to be effective as a management tool. Given multiple methods that are equally effective in achieving the same outcome, the method should be based on the experience, competence and preference by the performing organization responsible for developing and maintaining the schedule as well as managing the project. To do otherwise may cause inefficient management or additional work to maintain a vital artifact and tool necessary for effective project management. Mandating specific methodologies not only may increase cost but also is contrary to the principles of performance-based acquisition.

The fundamental conclusion for both the milestone and buffer task method of depicting Schedule Margin in the IMS is that they have equal validity. As long as either method provides

the necessary information to meet the management and analysis needs for all stakeholders, then it should be the responsibility of the performing organization that manages the activities contained in the schedule to apply their internal best business practices for determining and depicting Schedule Margin.

1. The milestone method for incorporating Schedule Margin is a valid method, but does not promote critical path stability and may increase perturbations in the schedule thus increasing risk.
2. Buffer tasks inserted at strategic points in the schedule, such as on nodes entering the critical path, serve to protect the critical path from perturbation by non-critical tasks. Essentially, buffer tasks serve to decrease change in the critical path through buffer consumption.
3. The definition of Schedule Margin in *DI- MGMT-81650* is ambiguous because it identifies margin both as a buffer and as the difference between milestone dates. The word “buffer” appears to be intended as a cushion rather than a buffer task. Because the definition specifically refers to contractual dates, it may be construed to prohibit margin that is not referenced to contractual milestones. This is in conflict with the guidance found in the *NASA Scheduling Handbook* and accepted practice throughout the project management industry.
4. Schedule Margin in the form of buffer tasks have a beneficial effect on schedule analysis by permitting the analysis to be conducted on a risk-based schedule with visible buffers. Because buffers are visible, it is simple to filter the buffers to facilitate analysis without them. In addition, the visibility of buffers provides an opportunity for increased insight and proactive adjustments by monitoring buffer consumption.

RECOMMENDATIONS

1. Revise **DI-MGMT-81650** to clarify the acceptability of the use of buffer tasks.
2. Revise the *NDIA Intent Guide* to clarify the use and depiction of schedule margin.
3. Revise government guidance, such as the **Earned Value Management Implementation Guide (EVMIG)**, to adequately address schedule margin.
4. Establish consistent guidance throughout Federal Government agencies.

